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Merrimack River Basin Overview

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River Basins Commission

June 30, 1978

NEW ENGLAND RIVER BASINS COMMISSION

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June 30, 1978

To the people of the Merrimack River Basin:

The New England River Basins Commission has initiated a basin planning program designed to maintain a continuing assessment of the problems, issues, and opportunities associated with the Region's water resources. Basin overview reports will be the initial products of this effort.

The Merrimack River Basin Overview concentrates on identifying gaps in the existing network of planning and resource management programs, and advances recommendations to correct these deficiencies. As such, it constitutes a guide to additional planning. The overview will also be used to assist in the coordination of state and federal planning efforts, providing the basis for the investigation of interstate resource issues and support for the Commission's annual priority program.

This report was developed by the New England River Basins Commission and accepted on June 30, 1978 as a prototype for future basin overviews and as an assessment of the Merrimack Basin. The Merrimack River Basin Overview has undergone two separate reviews. The first involved members of the Commission, and the second included the Commission, other state and federal agencies, and areawide and private interests. All comments were considered in completing the final report.

The cooperation of the participants in this effort is greatly appreciated. I hope that all will find the Merrimack Overview to be a useful source of information and the basis for future constructive action.

Respectfully Submitted,

John R. Ehrenfeld

John R. Ehrenfeld
Chairman

MERRIMACK RIVER BASIN OVERVIEW

NEW ENGLAND RIVER BASINS COMMISSION

June 30, 1978

Acknowledgements

Our appreciation is extended to the many government agencies, private organizations and individuals whose past efforts and cooperation have provided the basis for developing this overview. The information and reports provided by the Army Corps of Engineers, Soil Conservation Service, Environmental Protection Agency and the U.S. Geological Survey number among the many important federal contributions to this report. The reports of the Massachusetts Executive Office of Environmental Affairs, the New Hampshire Water Supply and Pollution Control Commission and allied state agencies proved central to developing a closer understanding of state interests and programs of relevance to the Merrimack. Special thanks is extended to the New Hampshire Office of Comprehensive Planning for their cooperation in providing open file and mapped information developed through the New Hampshire State Guide Plan Program. The reports of the several basin RPAs have also played an important role in the compilation of this document, and their cooperation in providing information and sharing their views on the Merrimack is greatly appreciated. The special contributions of all agencies and individuals are credited in footnotes throughout the text of this report and summarized in the Appendix A bibliographic references list.

NERBC staff members who have contributed to the development of this report include the following:

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1.0 Preface

The New England River Basins Commission is a federal-state planning partnership composed of representatives from ten federal agencies and six interstate or regional agencies. Gubernatorial appointees represent the six New England states and the State of New York. Under the provisions of the Water Resources Planning Act of 1965, NERBC was created to prepare and update plans for managing the region's water and related land resources. In addition, the Commission recommends long range priorities for meeting the region's most important natural resource information, planning and management needs.

To fulfill a portion of this mandate, the Commission is preparing summary reports on each of the region's major river basins. These overviews will establish a uniform information base with respect to demands on water resources, problems associated with the use of resources, and programs and projects relevant to the management of water in each of the Region's major river basins. The effort concentrates on identifying gaps in the existing network of planning and resource management programs, and advances recommendations to correct these deficienies. In this way, the overviews will constitute a guide to additional planning. They will be used to assist in the coordination of state and federal planning efforts, providing the basis for the investigation of interstate resource issues, and support for the Commission's annual priority program.

Basin overviews are not developed as elements of the Commission's regional plan (CCJP). They are guides to additional planning rather than plans for the management of water resources. As such, they do not consider a range of alternatives, nor are they subject to the 90-day review provisions of The Water Resources Planning Act (PL 89-80). The overviews

will not be used to implement the consistency policies recently approved by the Water Resources Council.

The report is organized as follows: the summary section (2.0) introduces the basin and its major water related issues. The recommendations of this section are directed to those issues which involve the interaction of several resource demands or management programs and hence transcend the functional categories discussed in the main body of the report. Following the summary is a description of the basin (3.0) dealing with the major physical and socioeconomic characteristics influencing the availability and use of its natural resources. This portrait serves as the basis for the discussion of eleven water related issues or demands (4.0), ranging from water supply to mineral extraction. The existing conditions, plans and programs related to each of these topics are reviewed and recommendations are made in the categories of data needs, planning, feasibility studies and action. To the extent that regional issues are manifest in the basin, recommendations have been formulated to address them. The final section (5.0) examines the uses of the Merrimack River and its shorelands in order to determine, in conclusion, how natural resource demands and the related planning and management efforts, discussed in the previous chapters, have focused on this area.

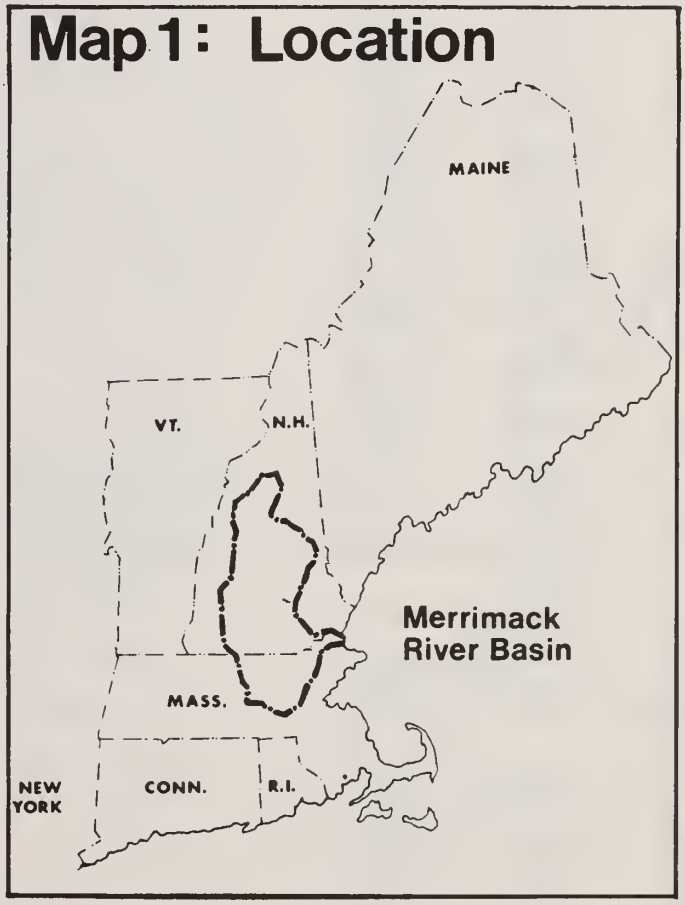
The main report is supplemented by two appendices. The first is a guide to the natural resource data relevant to the basin, consisting of a coded bibliography and index. This component of the overview is designed to provide a survey of basic planning and management information and a systematic process for reporting the availability and status of such data. The bibliography and index serve as guides to a series of reference maps and abstracts which are located in the Commission's offices and with appropriate agencies in the basin. The second appendix is a compendium of the specific recommendations in the report, organized by federal, state and regional agencies.

2.0 Summary

2.1 INTRODUCTION TO THE BASIN

The Merrimack River basin, covering some 5,010 square miles, stretches from the White Mountains of New Hampshire southward into the gentle hills of eastern Massachusetts (see Map 1). As the fourth largest basin in New England, the Merrimack contains a wide variety of landforms, hydrologic conditions, and land use patterns.

The basin is approximately 134 miles long, from north to south, with a maximum width of 68 miles from east to west. It is bounded by the Connecticut River basin on the west and northwest, the Saco and Piscataqua River basins on the northeast and east, the New Hampshire and Massachusetts coastal areas on the east and southeast, and the Blackstone River basin on the south. The 75 percent of the basin lying in New Hampshire contains most of the state's lakes and ponds as well as some of it's most important recreational attractions. Remote trout ponds, isolated mountain peaks and the broad expanses of Lake Winnipesaukee are just a few of the

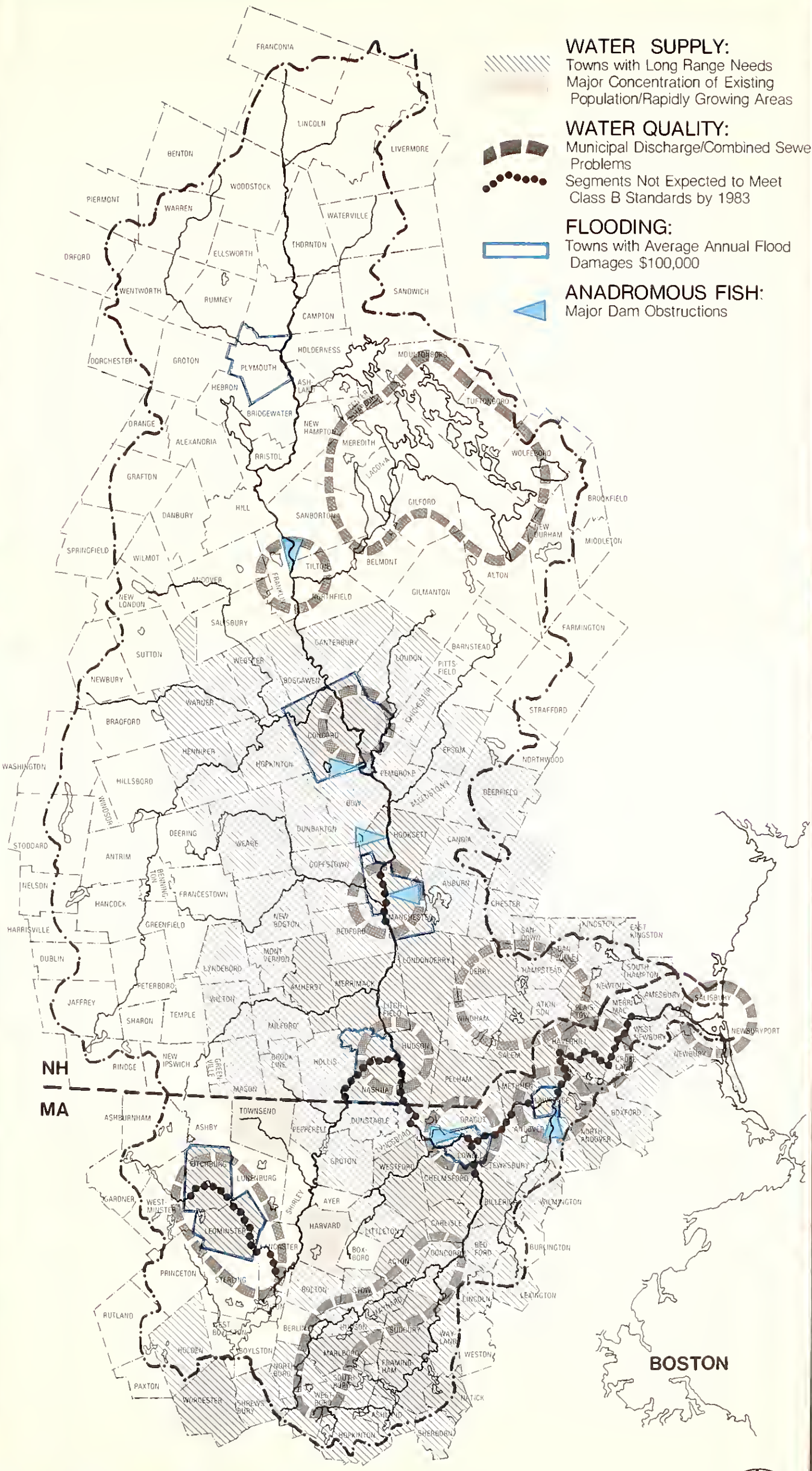


natural resources which draw thousands of tourists annually into the basin. Farming and forestry continue to be important activities in the central portions of the basin, while along the Merrimack's main stem, through southern New Hampshire and into Massachusetts, the imprint of the country's industrial revolution remains in the form of large mill complexes and canal systems. Although these old industrial centers remain influential in their own right, the 25 percent of the basin in Massachusetts and the southernmost New Hampshire towns are, today, strongly influenced by the growth of the Boston metropolitan area. Suburban expansion and satellite industrial developments are characteristic of this southern portion of the basin. As evidenced by the variety of activities occuring in the basin, the Merrimack is many different things to many people. The demands for water supply, waste disposal, and recreation, just to name a few, generated by the basin's 1.5 million residents, are considerable and not without deleterious effects on the area's water resources.

It is the purpose of this report to provide, in overview form, a perspective which encompasses the many demands and pressures on the basin's water and related land resources. With this perspective it is hoped that relationships between these resources will become apparent and that these insights will benefit future management efforts.

Water pollution, escalating flood damages, rising demands for domestic and industrial water supply, along with other pressures for water use constitute significant problems in the Merrimack basin. Each of these concerns is examined in the following chapters to identify the specific planning, data collection and related actions necessary to effect improved planning and management within the basin. This chapter examines the special planning and management requirements arising from the interaction of several problems and demands within the basin.

Map 2 is a composite illustration of the major problems and demands, and similarly Map 3 depicts the major proposals, projects, and opportunity areas identified in the following chapters. As such, they depict an overview of the forces shaping the present and possible future management challenge in the Merrimack. In assessing this challenge, several concerns for future basin planning become evident.



Major Problems and Demands
Merrimack River Basin

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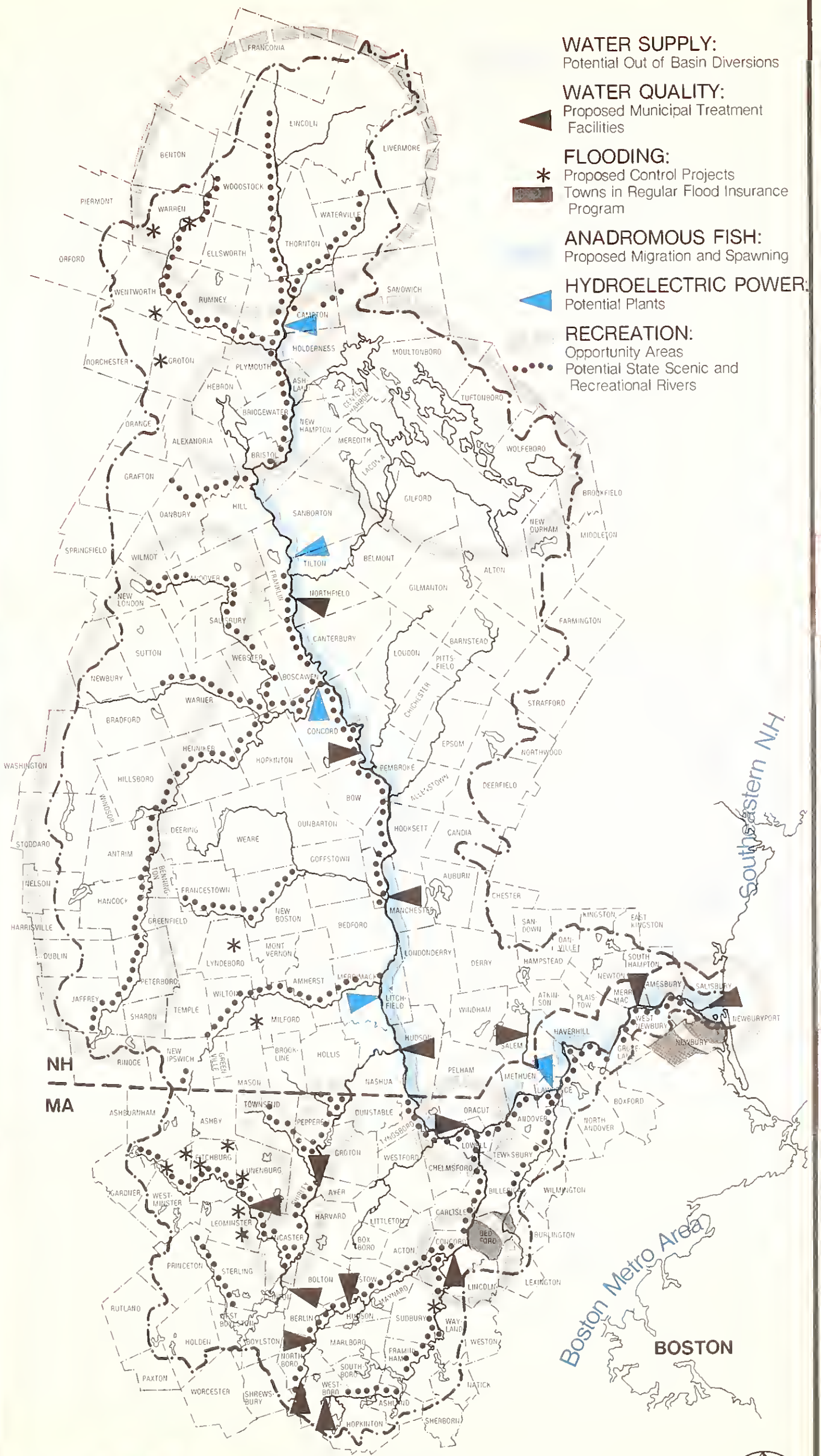

Proposals, Projects and Opportunities
Merrimack River Basin

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BASE MAP SOURCE:
USGS HYDROLOGIC UNIT MAP, 1:500,000 1974; TOWN LINES, NERBC, 1:500,000, 1976

3
MAP NO.

2.2 URBAN RELATED GROWTH ISSUES

The Merrimack's natural resource problems are most intense in the southern half of the basin where early mill-based industrialization and recent growth trends have formed a broad corridor of urban and suburban development along the main stem, and in the Nashua and SuAsCo subbasins. The by-products of this pattern of urbanization number among the most significant problems in the basin. The major problems and the programs they have set in motion include the following:

- Water quality is the most pervasive problem in this area and in the basin as a whole, preventing realization of the basin's full potential for water resource use. Forty-nine stream miles within the southern half of the basin are not expected to meet 1983 standards. Within the same area, there are 10 urban centers with ongoing combined sewer overflow or municipal discharge problems. An enormous investment in wastewater treatment facilities planning and construction has resulted in slow but steady improvements in water quality. The planning and construction process will carry into the basin's future as the states, RPA's and communities continue work toward achieving 1983 water quality standards. Section 208 planning programs and 16 proposed wastewater treatment facilities are immediate concerns in this area.

- The basin ranks 4th in the region in terms of present and projected annual flood damages, with the majority of the damages concentrated in 9 communities along the Nashua and main stem. An interstate compact agreement, signed in 1957, resulted in the construction of several upstream storage reservoirs in New Hampshire. However, flood damages continue to escalate in this area. The National Flood Insurance Program is the primary mechanism for flood plain management in the basin. At the same time, 14 flood control projects remain as potential structural solutions in the Nashua subbasin.

- As urban and industrial development continues, 99 towns in this area are expected to outgrow the capacity of their present water supply systems by 2020. With growing pressures for

domestic and industrial water supply, communities throughout the southern half of the basin have, or may in the future, develop or expand existing water treatment and distribution systems. The Merrimack may serve as a major source of supply in this area.

- Urban recreation demand has become an important concern in this area. Twelve rivers within the Massachusetts portion of the basin have been nominated as possible state scenic rivers, while Concord, Lowell and Newburyport have evolved as historic/recreation centers in the same area.

While each of these programs has been pursued as independent concerns by a variety of federal, state, local and private agencies, they share a common theme. They converge and overlap within the southern half of the basin, and each may affect or require certain stream flow characteristics. In that each of these concerns is a reflection of urban growth trends in the southern basin, it is imperative that no single issue dominate the planning and management efforts. As a consequence, tradeoffs among these and other programs may be the foremost management challenge in the basin's future. *To effect this tradeoff process, integration of the independent planning efforts and coordination among federal, state, local and private interests will be necessary.*

2.3 INTERSTATE STREAMFLOW ISSUES

Because the Merrimack is an interstate basin, the problems arising from the competition for water use may be compounded. While the majority of the foregoing programs will be of local or substate concern, three possibilities advanced in recent investigations may warrant special interstate cooperation in future planning for the basin.

- Two out-of-basin diversions for public water supply may limit future in-basin options for water use. While the diversions are uncertain possibilities at present, they have been advanced in eastern Massachusetts and in the coastal communities of

southeastern New Hampshire (alternative diversion sites are shown on Map 3). The activation of either diversion must be based on a balanced withdrawal plan that anticipates and provides for other in-basin demands on stream flow.

- An interstate program for the restoration of anadromous fish is gaining momentum in the basin in anticipation of improved water quality. The two states have joined with the U.S. Fish and Wildlife Service and National Marine Fisheries Service to develop a plan for the construction of fish passages over instream dams throughout the Merrimack main stem and on major tributaries (instream obstacles are identified on Map 2; Map 3 shows the extent of fish migration goals). Maintaining adequate stream flow and achieving state water quality goals will be critical factors in the success of this program. The anadromous fish restoration program will thus become a basic consideration in any project that may retard flow or impinge on water quality within the Merrimack's main stem.

- With the present emphasis on the development of native energy resources, the restoration or development of new hydropower installations has been viewed with growing interest (five potential hydropower plant sites are identified on Map 3). While this possibility has not been fully investigated, it may loom in the Merrimack's future as a major pressure on stream flow. Future hydropower development will have to be balanced with other flow dependent uses within the basin.

Each of these potential activities may warrant separate interstate agreements within which advanced planning and project implementation can be achieved. However, there is the possibility that they will converge on the Merrimack in competition with one another and with other in-basin uses of stream flow. The intensity of this competition for resources will be shaped largely by time. It will be most apparent if each of the activities outlined above occurs in the same time frame. However, this is unlikely. The time frames outlined below for these three concerns indicate that the danger is not acute competition for the water resource but rather

a progressively more exclusive allocation of resource potential with the effect of closing off important options in the future.

The demands for water supply are now generally met throughout the basin. Adjacent areas of demand, such as coastal New Hampshire and the Boston area, are exploring supply options which do not include the Merrimack as an active project. Nonetheless, long-term population growth both within and adjacent to the basin may generate the demand for expanded development of the basin's water supply potential. The degree to which this resource has been committed to alternative uses is clearly critical to the well-being of the area.

In contrast to the long-term nature of the water supply issue, both the anadromous fisheries project and the hydroelectric initiative have immediate relevance and impact. Already, as at the Essex Dam renovation project in Lawrence, Massachusetts, accomodations have been made to allow both efforts to go forward. To differentiate the time frames of these two programs, their inherent characteristics must be examined. The effort to reestablish hydropower as an important component of the region's energy mix is progressing on a site-by-site basis. Projects in the headwaters of the Merrimack can conceivably be undertaken at the same time as projects along the lower main stem. On the other hand, the restoration of the anadromous fisheries depends upon the provision of unobstructed passage from spawning habitat to the ocean. Although research populations can be established in isolated reaches of the river, successful restoration will involve a phased effort to construct fish passages, maintain flows, and protect habitat beginning in the lower main stem area and progressing upstream.

If it appears that the first water development efforts will capture all the benefits, it should be noted that these activities are not mutually exclusive. Hydroelectric technologies exist which have minimal impacts on fisheries and on the river's flow regime. With adequate forethought, water supply options can be maintained while developing hydropower sites and restoring anadromous fisheries. *Achievement of this goal, however, can only occur within the context of comprehensive, integrated water resources planning and management within both states. In addition, close cooperation is needed between the states and federal agencies. To anticipate this coordinated effort, a broad interstate agreement is needed embracing balanced consideration for these and other water uses.*

3.0 Description of the Basin

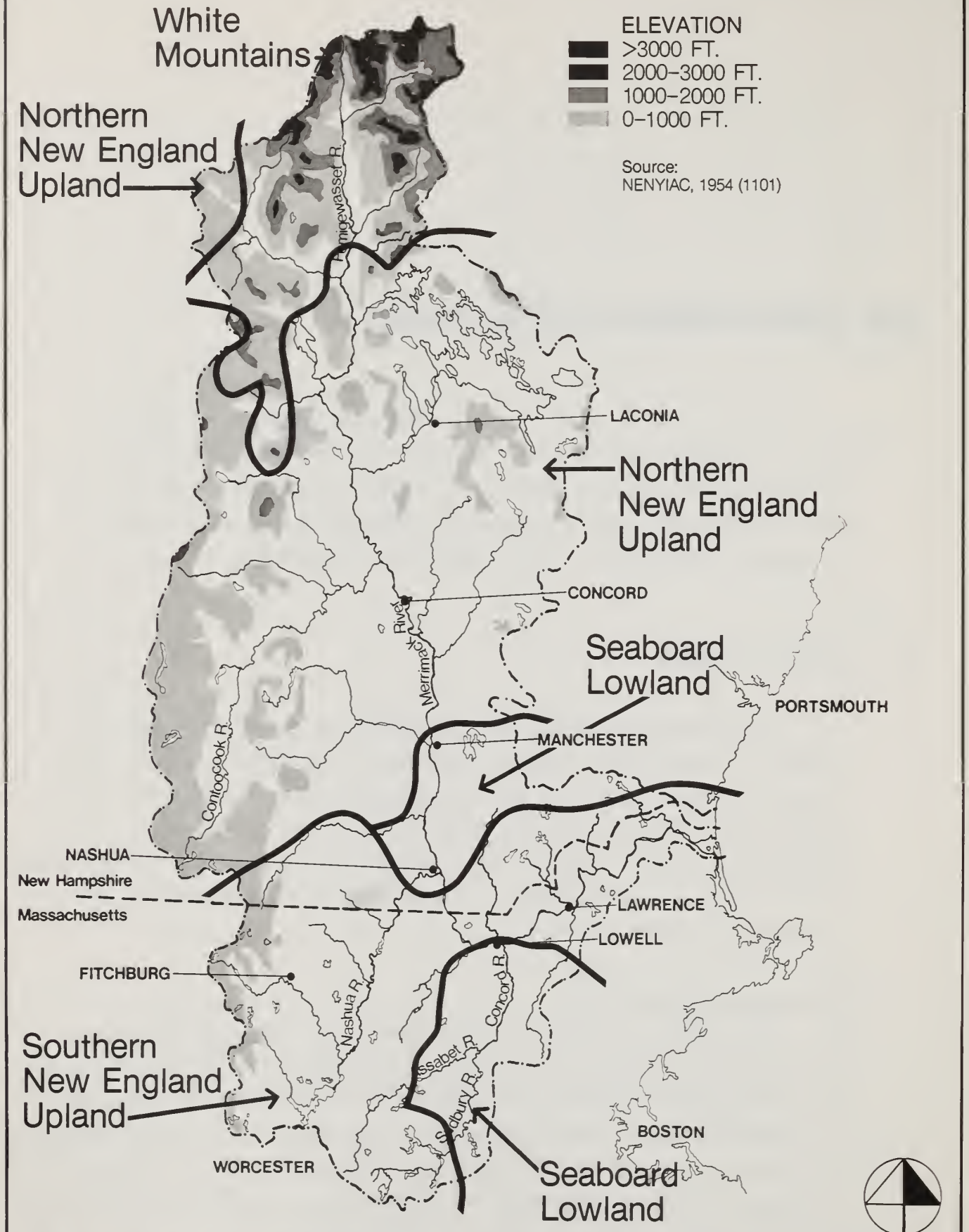
Physical, social, and economic conditions have interacted to determine present patterns of settlement in the Merrimack and will likewise shape future demands upon the basin's natural resources. The following sections summarize the unique physical, social, and economic characteristics of the Merrimack River basin.

3.1 PHYSICAL SETTING

The Merrimack basin's physical setting is comprised of two extremes, mountainous terrain to the north and coastal plain at the river's terminus. Between the two extremes a transitional terrain of moderate to rolling topography characterizes the majority of the basin's land area. This section highlights major physical characteristics of the basin as a background for the discussion of demands upon the Merrimack's natural resources.

3.1.1 Topography and Land Form

The headwaters of the Merrimack rise in the White Mountains forming the Pemigewasset River and its principal tributaries, the East Branch Pemigewasset, Mad and Baker Rivers (see Map 4). Glacial erosion has carved a rugged terrain in this region, with peaks reaching elevations of 4,000 to 5,000 feet above steepwalled river valleys. Mt. LaFayette, at the northernmost tip of the basin, is the highest of the basin's peaks at 5,249 feet. The Pemigewasset River falls



Physiographic Regions
Merrimack River Basin

0 miles 5 10

BASE MAP SOURCE:
USGS HYDROLOGIC UNIT MAP, 1:500,000, 1974; TOWN LINES, NERBC, 1:500,000, 1976.

4
MAP NO.

approximately 1,200 feet in its upper 10 miles through narrow valleys of exposed bedrock. All streams in this area can be characterized as clean, fast flowing mountain streams.

At the confluence of the Pemigewasset and Mad Rivers, the basin's topography begins to change to the Northern New England Upland province. The terrain in this area is rough and steep with a topographic relief of 400 to 800 feet and maximum elevations of 2,000 feet. In the northeastern section of this area Lakes Winnipesaukee, Squam, and Winnisquam occupy a major depression scooped out of the land surface by glacial action. Lake Winnipesaukee is the second largest lake in New England with a surface area of 72 square miles. The main stem of the Merrimack River is formed by the confluence of the Pemigewasset and Winnipesaukee Rivers at Franklin, New Hampshire. The main stem descends southward through a more moderate terrain with relief varying between 200 to 300 feet. The river valley gradually broadens in this area forming a wide corridor through the center of New Hampshire. The Contoocook, Soucook, Suncook, and Piscataquog Rivers drain the southern half of this area.

In the Southern New England Upland area, the terrain becomes hilly to gently rolling. Tributaries meandering across relatively flat areas of glacial outwash have cut broad valleys and flow generally in a northeasterly direction to the Merrimack main stem. The Nashua is the major tributary in this area, flowing out of the southwest corner of the basin to its confluence with the main stem at Nashua, New Hampshire. The Merrimack turns eastward just south of the Massachusetts state boundary and flows toward the coast. The river is tidal for the 22 miles below Haverhill with a mean tidal range of 7.9 feet at the mouth and 5.1 feet at Haverhill. The river widens as it passes through the estuarine zone at Newburyport and finally flows through a narrow channel between Plum Island and Salisbury Beach into the Atlantic Ocean.

To the north and south of the lower main stem are areas of Seaboard Lowland. These areas tend to be gently rolling or level with a few, low rough hills occurring at inland locations. The

tributaries in these areas, notably the Assabet, Sudbury, and Concord Rivers, are sluggish, in some instances falling only one inch per mile. Fresh and saltwater wetlands are common features in this landscape. The Shawsheen River, for example, has the most extensive wetlands of the Merrimack basin, with 13% of its drainage area in wetlands.

3.1.2 Surface and Groundwater Hydrology

The three water regimes, atmospheric, surface, and subsurface, are linked through climate, evapotranspiration, and runoff to form the self-renewing hydrologic cycle. A clear understanding of the components of the cycle and their relationship to each other is essential to good water management.

Climate controls the release of atmospheric water in the form of precipitation in the basin. The Merrimack receives an annual average of 43 inches of precipitation with the northern areas averaging slightly more (46") and the southern areas slightly less (41"). Although precipitation is evenly distributed throughout the year, the water in snowfall is stored through the winter months for release during spring freshet. During the months of March, April and May, rainfall combines with the spring snowmelt to release 50% of the basin's average annual runoff. Most of the basin's major floods have occurred during these months with the maximum flood of record set in March of 1936. However, heavy rainfall associated with tropical storms has also caused flooding at other times of the year, as in the hurricane related flood of September, 1938. Minimum flows generally occur in the months of September and October. Droughts have occurred intermittently in the past with major dry spells in 1929, 1939, 1949, 1957, and 1961 through 1965.

The average annual runoff, 21 inches, represents approximately 51% of annual precipitation. The remainder is returned to the atmosphere either by direct evaporation or by transpiration from vegetation. Temperature, a critical factor in determining evapotranspirative rates, varies at an annual average between 43° and 50° F. Table 1 illustrates the climatic character of the basin.

Table 1: Climatic Characteristics

	Lincoln NH	Woodstock NH	Franklin NH	Concord NH	Nashua NH	Haverhill MA
Elevation (feet)	830	720	390	339	140	60
Average Annual Temperature	-	-	44.7°F	44.8°F	47.1°F	50.8°F
Range of Average Monthly Temperature	-	-	19.9° - 69.5°F	20.1° - 69.0° F	23.9° - 70.5°F	28.0° - 73.8°F
Average Annual Precipitation	46.09"	-	39.92"	37.23"	42.13"	40.51"
Average Annual Snowfall		98"	70"*	61"	65"	53"

* elevation 430'

Source: NHWSPCC 303 (e), 1973 [3110]

The Merrimack basin's runoff flows through the interconnected system of surface and groundwaters. Although surface waters are the most visible manifestation of runoff and available water supply, they are derived primarily from groundwater via subsurface flow. National surveys estimate that 60% of stream flow comes from groundwater. An unresolved planning and management problem centers around the lack of a clear understanding of the basin's groundwater hydrology. This inadequacy stands in stark contrast to the detailed knowledge of the Merrimack's surface waters.

As shown on Map 5, the Merrimack main stem constitutes an axis in the basin, connecting five principal tributaries, and ultimately channeling an average flow of 4,900 mgd to the Atlantic Ocean. Table 2 summarizes the availability of surface water in terms of stream flow and storage capacity for the 13 gaging stations indicated on Map 5. The total storage capacity of the major surface water bodies is 384,900 acre-ft. This storage is used for power generation, recreation and water supply. An additional 212,800 acre-ft. of storage capacity is available for flood control.

Although extensive inventories of groundwater resources have been completed, quantitative estimates of groundwater, comparable to the surface water flow rates and storage capacities are not available. Groundwater is extensively used for public water supply; 43 of the 98 towns with public water supply systems rely exclusively on groundwater sources. However, it is generally considered a limited resource suited primarily to the needs of small towns and individual households.

3.1.3 Intervention in the Hydrologic Cycle

The natural flow of water through the hydrologic cycle has been considerably altered by man's intervention in the Merrimack basin. While the cumulative effects of modifications in the system are not well understood, the following summarizes the location and types of major modifications in the Merrimack.

NO. 1-13 SEE REFERENCE TABLE 2
Pemigewasset Sub-basin 1085 sq. mi.
Winnipesaukee Sub-basin 435 sq. mi.
Contoocook Sub-basin 766 sq. mi.
Merrimack Sub-basin 1799 sq. mi.
Nashua Sub-basin 530 sq. mi.
SuAsCo Sub-basin 395 sq. mi.
East Branch
Pemigewasset R.
Mad R.
Baker R.
Squam Lake
Newfound Lake
Lake Winnipesaukee
Lake Wentworth
Paugus Bay
Winnisquam Lake
Silver Lake
LACONIA
Blackwater R.
Warner R.
Soucook R.
Suncook R.
CONCORD
Merrimack River
Highland Lake
N. Branch
Nubanusit Lake
Contoocook R.
S. Branch
Piscataquog
MANCHESTER
Massabesic Lake
Souhegan R.
Island Pond
Beaver Blk
Little R.
Powwow R.
PORTSMOUTH
estuarine
NASHUA
New Hampshire
Massachusetts
Nissitissit R.
Squannacook R.
Stony Brook
Shawsheen R.
LAWRENCE
LOWELL
FITCHBURG
N. Nashua R.
Nashua R.
Concord R.
Assabet R.
Sudbury R.
Wachusett Reservoir
Sudbury Reservoir
WORCESTER
BOSTON
1
2
3
4
5
6
7
8
9
10
11
12
13
0 miles 5 10
BASE MAP SOURCE: USGS HYDROLOGIC UNIT MAP, 1:500,000, 1974; TOWN LINES, NERBC, 1:500,000, 1976.
5
MAP NO.
Surface Waters
Merrimack River Basin

Table 2: Hydrologic Characteristics

	Drainage Area (mi^2)	Maximum Instantaneous Flow (cfs)	Average Daily Flow (cfs)	7 Day 10 Yr. Low Flow (cfs)	Surface Water (acres)	% of Total Drainage
1. Pemigewasset (Plymouth, NH)	622	65400	1333	112	1510	0.4
2. Winnipesaukee (Tilton, NH)	471	3810	677	200	58758	18.9
3. Contoocook (Penacook, NH)	766	46800	1231	93.9	6150	1.2
4. Piscataquog (Goffstown, NH)	202	21900	297	7.9	1612	1.1
5. Souhegan (Merrimack, NH)	171	16900	279	13*	410	0.4
6. Soucook (Concord, NH)	76.8	2880	106	3.2	-	-
7. Suncook (N. Chichester, NH)	157	12900	237	4.5	2515	2.5
8. Nashua (E. Pepperell, MA)	433	20900	503	1.1*	8442	3.0
9. SuAsCo (Lowell, MA)	405	3790	434	7*	6888	2.6
10. Shawsheen (Lawrence, MA)	73	-	-	-	296	0.6
11. Merrimack (Franklin Jct., NH)	1507	83000	2724	589	74118	7.7
12. Merrimack (Lawrence, MA)	4461	174000	6661	51*	112870	3.8
13. Merrimack (Newburyport, MA)	5010	-	-	-	117382	3.7

* Daily low flow

Source: NENYIAC, 1954 [1301]
NHWSPCC 303 (a), 1973 [3110]

Note: Refer Map 5 for location of gaging station

In the Merrimack River basin, major intervention in the hydrologic cycle has taken the form of a multitude of dams for flood control, power generation, water supply and other purposes. Some 350 impoundments alter the original flow patterns of the basin with a variety of resultant effects. Map 6 shows the location of principal dams while Figure 1 illustrates the impact of impoundments on the river profile. The major dams along the main stem and larger tributaries were originally designed to harness the river to drive electrical generating facilties. The installed generating capacity today is approximately 71 megawatts. These dams along with various flood control projects have had the general effect of evening the discharge (flow) rates over time. Although these impoundments increase the apparent availability of surface water, they also result in increased evaporative loss and, around reservoirs, raise the local groundwater level.

Intervention also takes the form of diversions. The MDC diverts the runoff of approximately 108 mi^2 for the water supply of Boston. The actual quantity of water diverted in or out of the basin is not easily obtainable. Although the MDC does utilize the Wachusett drainage for its Boston system, it also supplies all of the water to Southboro, Clinton, and Framingham, as well as partial supplies to Marlboro, Northboro, Leominster and Lancaster. The Pinehill Reservoir in Holden supplies Worcester in the Blackstone River basin, representing an out-of-basin diversion. Fitchburg, on the other hand, diverts water from the Miller's River basin in the Connecticut River system for its water supply. The MDC also provides centralized out-of-basin wastewater treatment facilities for Framingham, Natick and Ashland which represents an outgoing diversion.

Although the impacts of these diversions have not been assessed, the potential effects of further major diversions may be significant. Further planning for diversion projects should establish minimum stream flow standards to assure maintenance of existing assimilative capacity, downstream water supply, and fish and wildlife habitat.

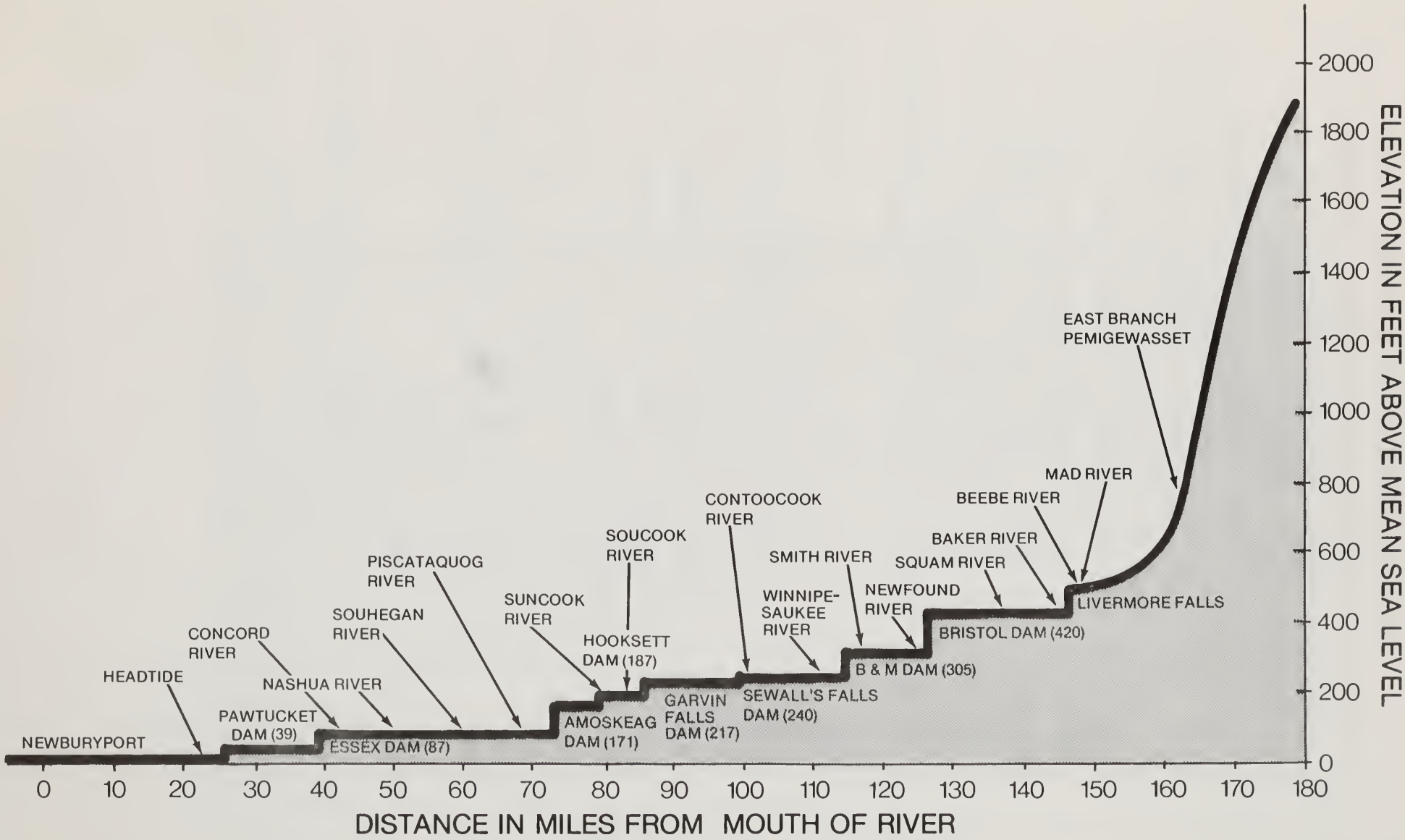
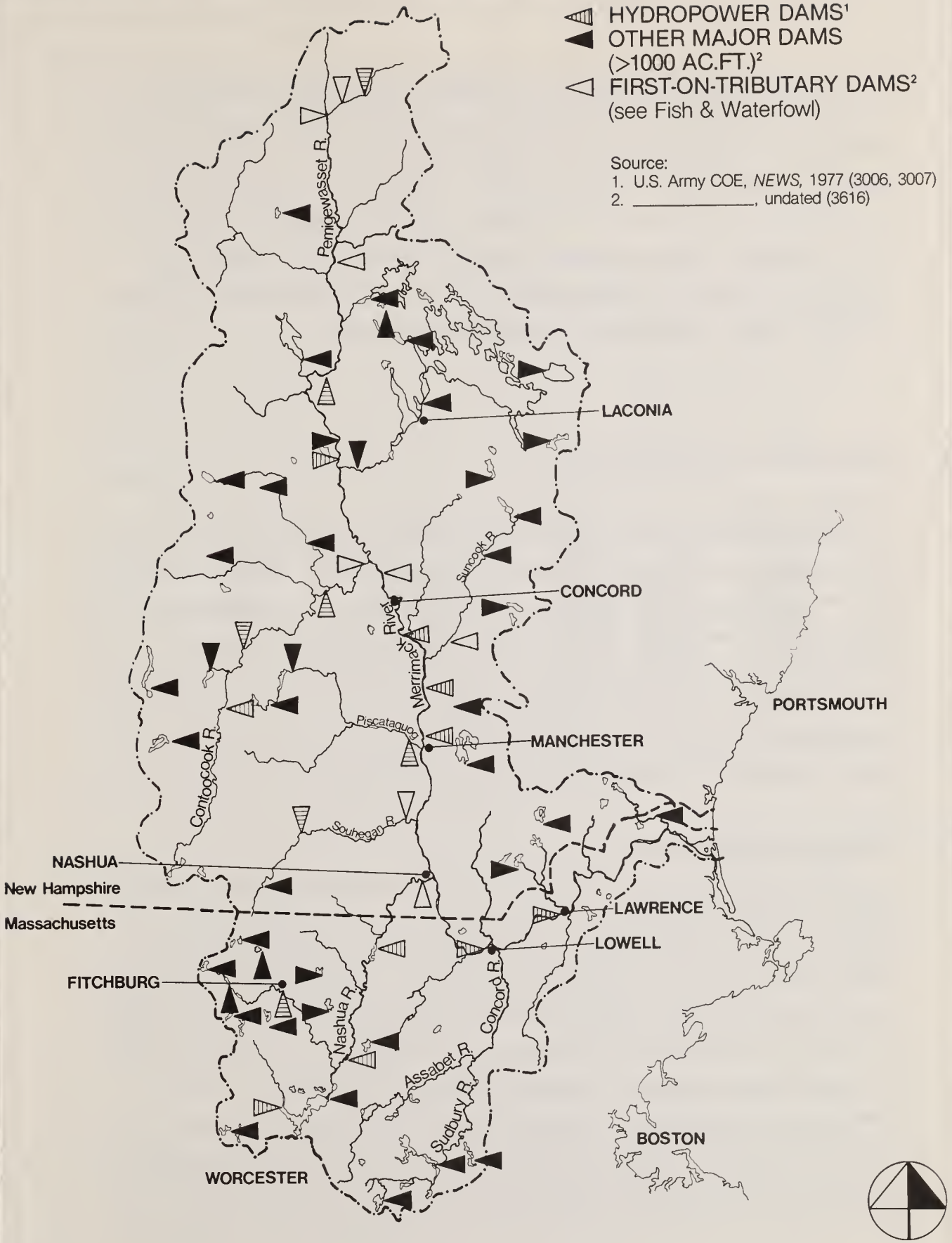


Figure 1: River Profile



Selected Dams
Merrimack River Basin

0 miles 5 10

BASE MAP SOURCE:
USGS HYDROLOGIC UNIT MAP, 1:500,000. 1974; TOWN LINES, NERBC, 1:500,000, 1976.

6
MAP NO.

A third possibility for intervention in the hydrologic cycle concerns the withdrawal of groundwater. The aquifers tapped by well systems are recharged at a rate determined by local geologic and climatic conditions. It is possible to determine a sustained yield for an aquifer which would represent a balance between recharge and withdrawal. Withdrawals in excess of this level result in a lowering of the water table with potential impacts on surface waters supplied by the aquifer and on groundwater quality.

3.2 SOCIOECONOMIC CHARACTERISTICS

The physical configuration of the basin in combination with the socioeconomic influences of the Boston Metropolitan Area have left a clear imprint on the character of development in the Merrimack. The following sections trace the history of development in the Merrimack and summarize present demographic and economic conditions in the basin. The final summary section of this chapter inter-relates physical and socio-economic factors in a discussion of the present pattern of development in four major areas of the basin.

3.2.1 History of Development

The agrarian base of the region's early economy dictated a dispersed settlement pattern located primarily in the southern and central portions of the basin where fertile soils and accessibility favored the growth of a farm-based economy. From the early 1600s until 1850, the small towns scattered throughout this area functioned as trade and transportation centers. Over half of the land area of the basin was cleared for cultivation during this period. This clearing and the methods of farming have left a legacy of small ownership patterns which persists to this day. By 1850, the early trade centers of the basin had grown to centers of industry and offered many new manufacturing jobs. At the same time, improved

transportation facilitated the import of produce from more fertile midwestern farm lands. As a result, agricultural activity in the Merrimack, as well as all of New England, diminished and the farmlands slowly reverted to forest. Today, forests cover 80% of the basin versus the 50% of the early 1800s.

While agricultural activity was concentrated in the river valleys of the southern basin, the resources of the northern portions supported extensive forestry and trapping operations. These activities also diminished over time leaving the scenic beauty of the northern Merrimack as a prime basin resource. The Lakes region evolved as a recreational center and presently supports a large seasonal population in extensive shoreline developments.

The river's power potential was harnessed at Manchester, Nashua, Lowell, and Lawrence to drive thriving textile industries during the mid-1800s. While the manufacture of textiles, paper and leather goods dominated the economic base of the main stem communities, the manufacture of paper became the prominent industry in Fitchburg and Leominster on the Nashua River. These cities and the adjacent communities continue to be the population and economic centers of the basin despite the decline of the textile and leather industries and subsequent shifts in industrial composition.

Within the basin, there has been a marked trend toward the formation of metropolitan ties among the southern tier communities. Concord, Manchester and Nashua are closely related by transportation linkages and economic ties, as are the Lawrence, Lowell and Haverhill areas and the Leominster-Fitchburg area. While these centers provide the retail and employment centers for the basin's rural hinterlands, they in turn constitute satellites of the Boston metropolitan area linked by Routes 9, 3, 128, 495, 95 and 93.

Most urban areas in the basin share the problem of declining downtown centers and aging "mill-era" industrial buildings vacated during the decline in the manufacture of textiles. Cities such as Lowell, Lawrence and Fitchburg are now exploring alternative ways of revitalizing their centers.

The proposals for the creation of an Urban National Cultural Park centering on the textile mills and canal system in Lowell are representative of these efforts.

3.2.2 Population

In 1975, a population of about 1.5 million people resided in the Merrimack River basin. The distribution of population among the two states has remained fairly stable over the past 15 years with Massachusetts accounting for about 70% and New Hampshire about 30% of the total population. Table 3 summarizes past growth in the basin as compared to broader state and nationwide patterns of growth. The population trends of the six Standard Metropolitan Statistical Areas (SMSAs) and the five largest towns in the basin are also presented in this Table.

During the period of 1960 to 1975, the basin's population grew at an average annual rate of 2.0% adding roughly 25,000 people per year during the 15 year period. After 1970, basinwide population growth declined to about 1% with about 16,000 people added annually through 1975. New Hampshire towns within the basin, as well as statewide, have experienced the highest growth rates during the two periods.

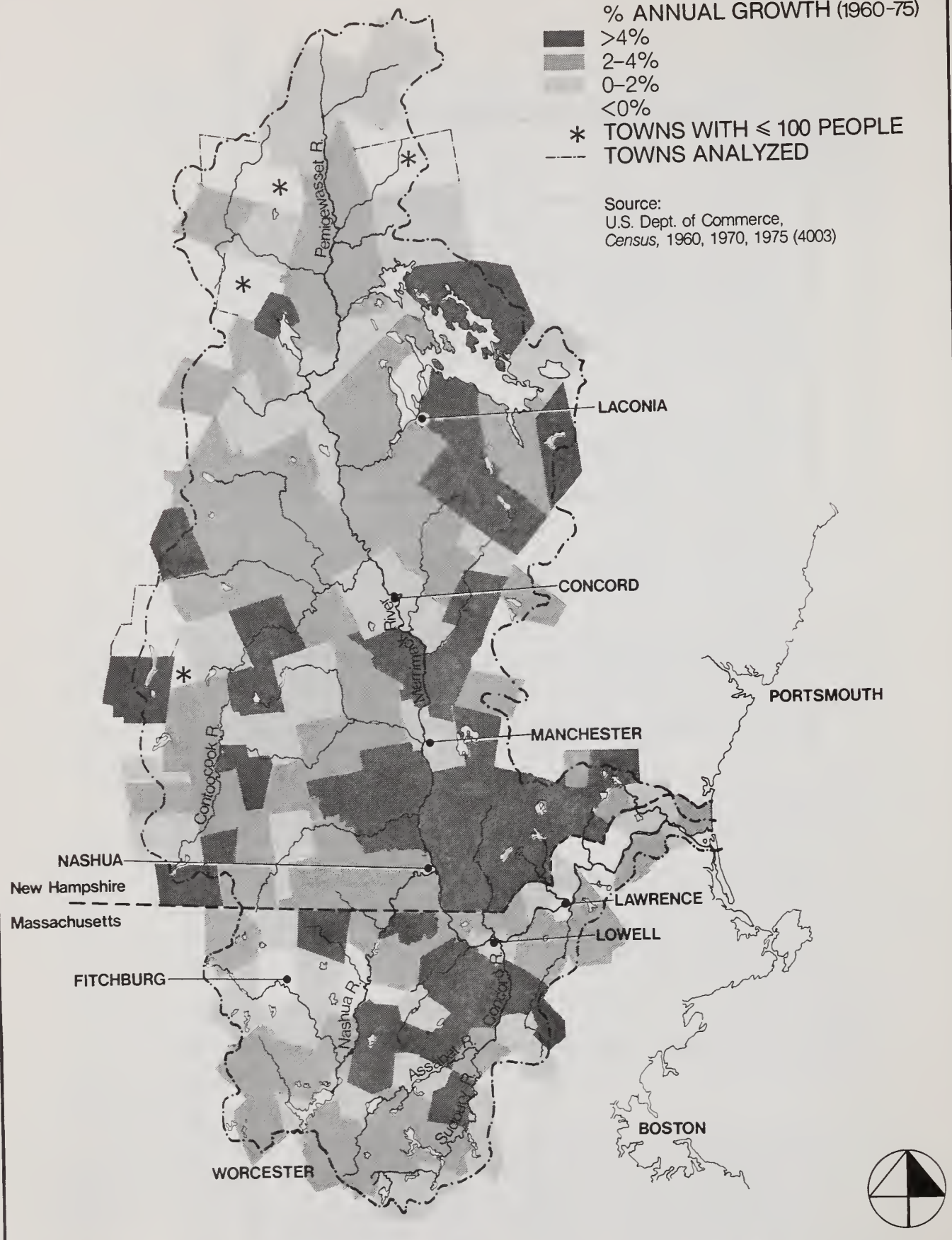
Map 7 illustrates the distribution of population growth throughout the basin and highlights those areas that have experienced more rapid growth rates than the basinwide 1960 to 1975 average annual rate of 2.0%. In New Hampshire, 79 towns have grown faster than the 2.0% average with 33 towns growing at a pace more than double the average rate. In Massachusetts, 36 towns grew faster than the average with 12 towns experiencing growth rates more than double the basin average. Massachusetts towns within the basin have grown more rapidly than the statewide average, but at a pace slower than New Hampshire and nationwide averages.

Map 8, showing population density, illustrates the effects of past growth rates on the present distribution of population in the basin. The majority of New Hampshire remains lightly settled with

Table 3: Population Growth 1950 - 1975

AREA	TOTAL POPULATION & % CHANGE							AVERAGE ANNUAL GROWTH RATES	
	1950	1960	%	1970	%	1975	%	60-75	70-75
United States	151,325,798	179,323,175	18.5	203,211,926	13.3	213,052,000	4.8	1.25	0.9
Massachusetts	4,690,514	5,148,578	9.8	5,689,170	10.5	5,812,489	2.1	0.75	0.4
New Hampshire	533,242	606,921	13.8	737,681	21.5	811,804	10.0	2.0	2.0
Merrimack Basin	925,036	1,126,710	21.8	1,410,321	25.2	1,491,143	5.7	2.0	1.0
MA Portion	630,970	794,839	25.9	982,185	23.5	1,021,659	4.0	1.75	0.75
NH Portion	294,066	331,871	12.8	428,136	29.0	469,489	9.6	2.25	2.0
SMSA's									
Fitchburg-Leominster	80,528	90,158	11.9	97,164	7.8	97,201	-	0.5	-
Lawrence-Haverhill	n/a	199,136	n/a	232,415	17.5	n/a	n/a	n/a	n/a
Lowell	140,249	164,243	17.1	212,860	29.6	222,167	4.4	2.0	1.0
Manchester, NH	93,338	102,861	10.2	108,461	5.4	106,951	-1.4	0.25	-0.25
Nashua, NH	38,852	44,972	15.7	66,458	47.8	72,617	9.3	3.25	1.75
Towns > 25,000									
Framingham	28,086	44,526	58.5	64,048	43.8	65,540	2.3	2.75	0.5
Marlborough	15,756	18,819	19.4	27,936	48.7	30,315	8.5	3.25	1.75
Natick	19,838	28,831	45.3	31,057	7.7	30,951	-0.4	0.5	-
Lexington	17,335	27,691	59.8	31,886	15.1	32,310	1.3	1.0	0.25
Concord, NH	27,908	28,991	3.9	30,022	3.5	29,321	-2.4	-	-0.5

Source: U.S. Department of Commerce Census, 1950, 1960, 1970, 1975 [4003]

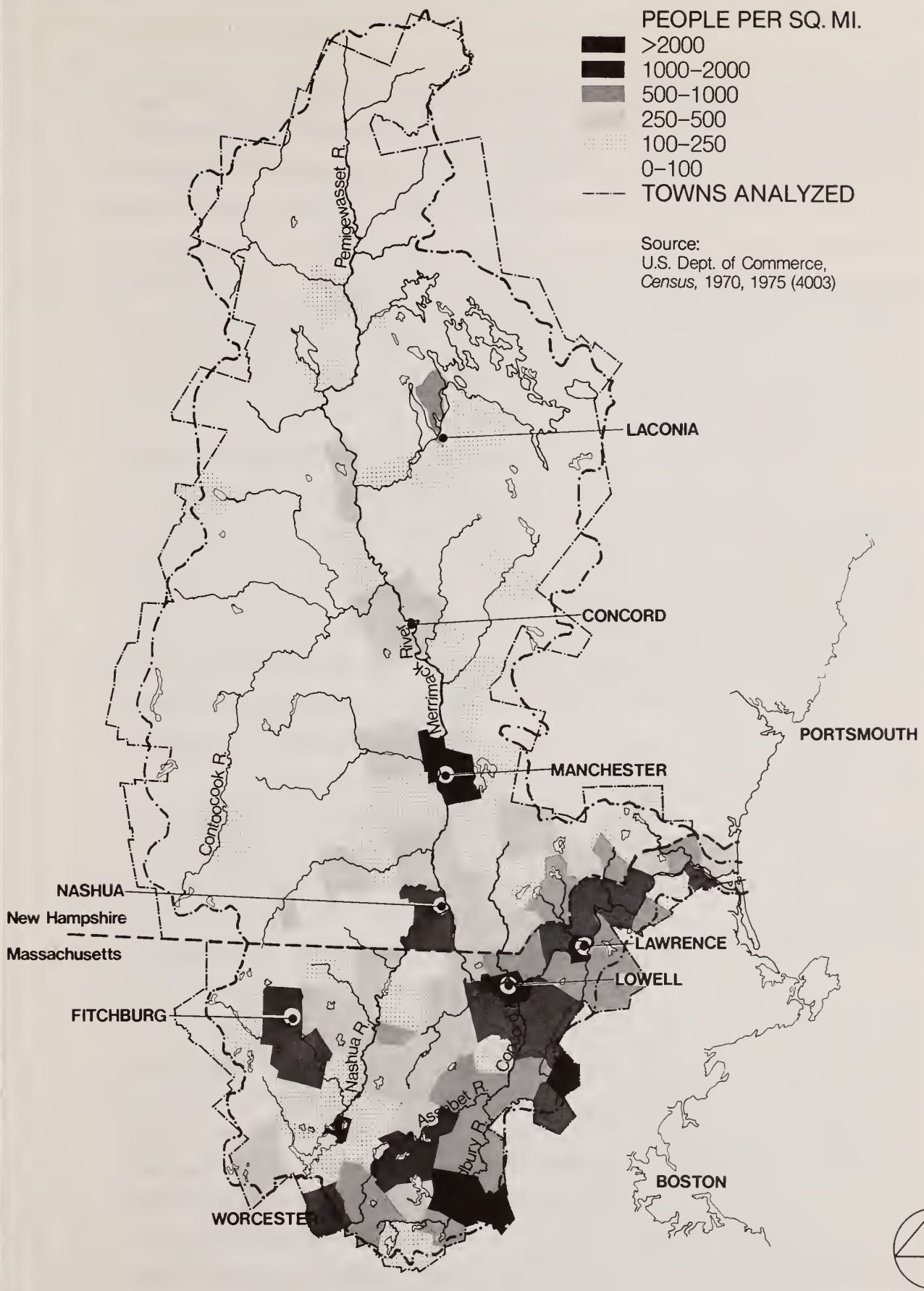


Annual Growth Rate
Merrimack River Basin

0miles 5 10

BASE MAP SOURCE:
USGS HYDROLOGIC
UNIT MAP, 1:500,000,
1974; TOWN LINES,
NERBC, 1:500,000, 1976.

7
MAP NO.



Population Density
Merrimack River Basin

0 miles 5 10

BASE MAP SOURCE:
USGS HYDROLOGIC
UNIT MAP, 1:500,000,
1974; TOWN LINES,
NERBC, 1:500,000, 1976.

8
MAP NO.

population densities of less than 250 people per square mile. However, in southcentral New Hampshire along the Merrimack main stem, population densities have grown to levels that contrast sharply with the rural character of the rest of the state. In this area, Concord, Manchester, and Nashua have developed as key centers of urbanization around which higher population densities have grown. Nashua and Manchester constitute SMSAs encompassing 2 and 4 towns, respectively, in the area. Salem and adjoining border towns have also developed as more densely populated areas and are presently linked with the Lawrence-Haverhill SMSA.

In Massachusetts, urban and suburban population densities prevail, with rural densities of less than 250 people per square mile intermixed throughout the area, but most dominant in the western half of the basin. In general, the towns immediately adjacent to the old population centers and those communities along Routes 9 and 128 have accounted for a large portion of the basin's growth (47.2% of the increase in population between 1950 and 1975 in 15 communities). This picture is changing, however, as growth pressures reach beyond this set of towns. Growth in these towns between 1970 and 1975 accounted for only 38% of the basin's population increase.

The principal socioeconomic forces shaping the distribution of population in the basin are the outward growth of the Boston metropolitan area and the economic vitality of the basin's industrial and commercial centers. These forces have concentrated the majority of past growth in the southern half of the basin. Sixteen communities in this area encompass only 6.3% of the basin's land area yet 49.7% of the basin's total population.

A final measure of the basin's total population is the annual influx of summer residents. Although accurate figures are difficult to obtain, the seasonal population increases are clearly large as evidenced by the major recreational service centers in the basin. Three areas absorb the majority of the seasonal rise in population: 1) the Lake Winnipesaukee region, 2) the western perimeter of the Contoocook subbasin extending from Rindge to Andover, and 3) the Newfound Lake region. In Massachusetts, the town of Salisbury is

the principal center of seasonal population increases. While estimates of summer population are not available for this area, the concentration of seasonal homes (55.5% of total housing in 1970) suggests that the annual influx is probably considerable.

3.2.3 Economics

The southern half of the Merrimack basin constitutes the northern terminus of the Atlantic seaboard "megalopolis" stretching northward from Washington, D.C. to the Boston metropolitan area. As such, the economic base of major basin employment centers is linked to a larger region that transcends the basin's boundaries and extends well beyond the seven state New York-New England region.

Recent total employment trends and employment by major industry classification are presented in the following text as an indication of the diversity and strength of the basin's economic base. National and state figures for New Hampshire and Massachusetts are provided as a comparative base for the information reported by in-basin jurisdictions. SMSAs and counties are the basic reporting units used to characterize the basin's economy.

As indicated in Table 4, the Merrimack Basin has experienced a steady increase in total employment during the period 1960-1970. The state of New Hampshire and four out of the five New Hampshire counties experienced the largest increases in total employment. Massachusetts statewide and county employment trends compare less favorably with nationwide and New Hampshire state averages, growing at a pace about 4% and 10% below those averages, respectively.

While total employment has steadily grown in the basin, it has not kept pace with rising demands for job opportunities. As indicated in Table 4 unemployment rates in 1975 and 1976 were in some instances more than double 1960 and 1970 rates. Massachusetts counties and SMSAs have experienced the highest rates of unemployment surpassing the national rate by as much as 5% in 1975.

Table 5 provides a summary of basin employment trends for nine major industry classifications. Figure 2 illustrates trends in the distribution of jobs among industries over the same period.

Table 4: Total Employed Civilian Labor Force & Unemployment Rates

	TOTAL EMPLOYMENT			UNEMPLOYMENT RATES			
	1960	1970	%	1960	1970	1975	1976
United States	64,639,252	76,553,599	18.4	5.1	4.4	8.5	7.7
Massachusetts	2,000,312	2,298,169	14.9	4.2	3.8	11.2	9.5
New Hampshire	234,444	294,124	25.4	4.3	3.5	7.1	5.0
Counties							
Essex	226,536	259,917	14.7	3.8	3.9	11.7	10.4
Middlesex	481,432	573,857	19.2	3.2	3.4	10.1	8.6
Worcester	228,147	256,541	12.4	3.9	3.8	11.9	9.7
Belknap	11,256	12,933	14.9	2.8	3.6	9.0	6.2
Grafton	18,259	21,838	19.6	4.1	3.4	6.1	4.6
Hillsborough	73,576	91,387	24.2	4.1	3.1	7.4	5.4
Merrimack	26,676	32,493	21.8	3.3	2.4	6.1	4.0
Rockingham	33,447	52,580	57.2	3.9	4.9	6.3	4.6
SMSA's							
Fitchburg-Leominster	32,289	39,210	21.4	3.0	4.2	13.4	10.4
Lawrence-Haverhill	78,776	97,863	24.2	3.6	4.1	13.6	12.6
Lowell	59,619	82,284	38.0	4.8	4.1	11.9	10.5
Worcester	123,831	139,667	12.8	4.0	3.6	11.1	9.2
Manchester	40,187	44,928	11.8	4.5	3.2	8.0	5.6
Nashua	-	27,588	-	-	2.8	6.7	5.7

Source: U.S. Department of Commerce Census, 1960, 1970 [4003]

Table 5: Employment Trends for Major Industries

AREAS:	Agriculture Forestry, Fisheries			Construction			Manufacturing			Transportation, Communications, Public Utilities			Finsnce, Insurance Real Estate		
	1960	1970	%	1960	1970	%	1960	1970	%	1960	1970	%	1960	1970	%
Massachusetts	26147	21823	-16.5	99823	121803	22.0	409268	671065	64.0	115464	132006	14.3	96307	132858	34.1
New Hampshire	7283	5666	-22.2	13501	20294	50.3	93185	104414	12.1	10803	13382	23.9	7871	11574	47.0
Counties:															
Essex	3381	2478	-26.7	10689	12476	16.7	94911	89671	-5.5	10827	13645	26.0	8590	12674	47.5
Middlesex	4471	3986	-10.8	25241	29840	18.2	154111	152645	-1.0	29080	32991	13.4	25889	33958	31.2
Worcester	3247	2633	-18.9	9607	12570	30.8	106199	98512	-7.2	10404	11945	14.8	7940	10592	33.4
Belknap	413	310	-24.9	724	1099	51.8	4239	4060	-4.9	530	583	10.0	325	386	18.8
Grafton	1008	646	-35.9	1143	1616	41.4	4799	5044	5.1	923	973	5.4	374	553	47.9
Hillsboro	1288	1047	-18.7	3711	6032	62.5	32323	35549	10.0	3636	4740	30.4	3028	4072	34.5
Merrimack	885	724	-18.2	1824	2534	38.3	8415	9163	8.9	1211	1255	3.6	1159	2056	77.4
Rockingham	1075	966	-10.1	2155	3785	75.6	12769	17719	38.8	1664	2839	70.6	1028	2046	99.0
SMSAs:															
Fitchburg	345	330	-4.3	1227	1921	56.6	16585	17174	3.6	1288	1590	23.4	762	1094	43.6
Lawrence	755	756	0.0	3153	4599	45.9	37843	38806	2.5	3085	4422	43.3	2214	3575	61.5
Lowell	614	578	-5.8	3250	4937	51.9	25049	30939	23.5	3472	4161	19.2	1688	2473	46.5
Worcester	1362	1355	-0.5	5160	6704	29.9	51156	45810	-10.4	6487	7209	11.1	5558	7356	32.3
Manchester	275	311	13.1	2142	3145	46.8	17040	14601	-14.3	2273	3028	33.2	1999	2670	33.6
Nashua		118			1407			12993			1074			881	

AREAS:	Wholesale & Retail Trade			Educational Services			Public Administration			Services		
	1960	1970	%	1960	1970	%	1960	1970	%	1960	1970	%
Massachusetts	346520	461932	33.3	113441	199941	76.2	94993	118057	24.3	132526	144785	9.2
New Hampshire	35750	54413	52.2	12861	24412	89.8	8690	12002	38.1	16293	18236	11.9
Counties:												
Essex	37878	53283	40.7	9962	18194	82.6	9651	13543	40.3	14874	14815	-0.4
Middlesex	83389	114197	36.9	34991	59681	70.6	24495	31721	29.5	33406	39022	16.8
Worcester	34876	48999	40.5	10966	19497	77.8	6887	8847	28.4	11915	13083	9.8
Belknap	1735	2612	50.5	663	1125	69.7	396	481	21.5	858	750	-12.6
Grafton	2782	3953	42.1	2162	3603	66.7	595	773	29.3	1704	1878	10.2
Hillsboro	11335	17089	50.8	2692	5392	100.2	2442	3823	56.5	4460	5026	12.7
Merrimack	4047	5556	37.3	1549	2794	80.4	1754	1999	14.0	1740	2177	25.1
Rockingham	5425	10568	94.8	1805	3996	121.4	1444	2361	63.5	2317	3207	38.4
SMSAs:												
Fitchburg	4777	7489	56.8	1233	2666	116.2	1306	1592	21.9	1576	1921	21.9
Lawrence	11600	18496	59.4	3117	6459	107.2	3561	5792	62.6	5001	5089	1.8
Lowell	8775	15305	74.4	2433	5019	106.2	3054	4907	60.7	3089	4690	51.8
Worcester	21355	28492	33.4	6362	11452	80.0	3987	5238	31.4	6989	7263	3.9
Manchester	6860	9210	34.2	1392	2606	87.2	1544	2163	40.1	2481	2651	6.8
Nashua		4773			1517			1118			1379	

Source: U.S. Dept. of Commerce Census 1960, 1970 [4003]

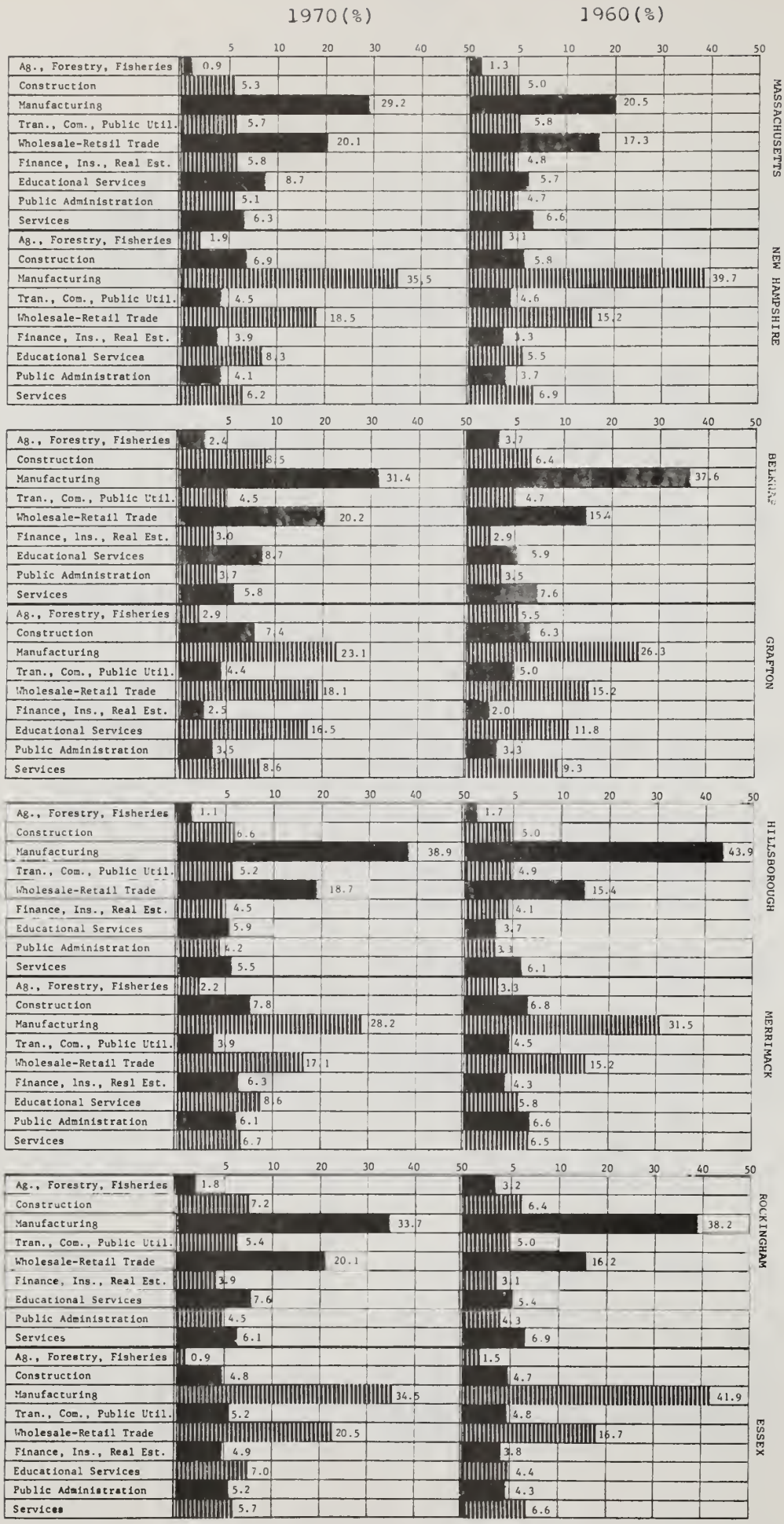
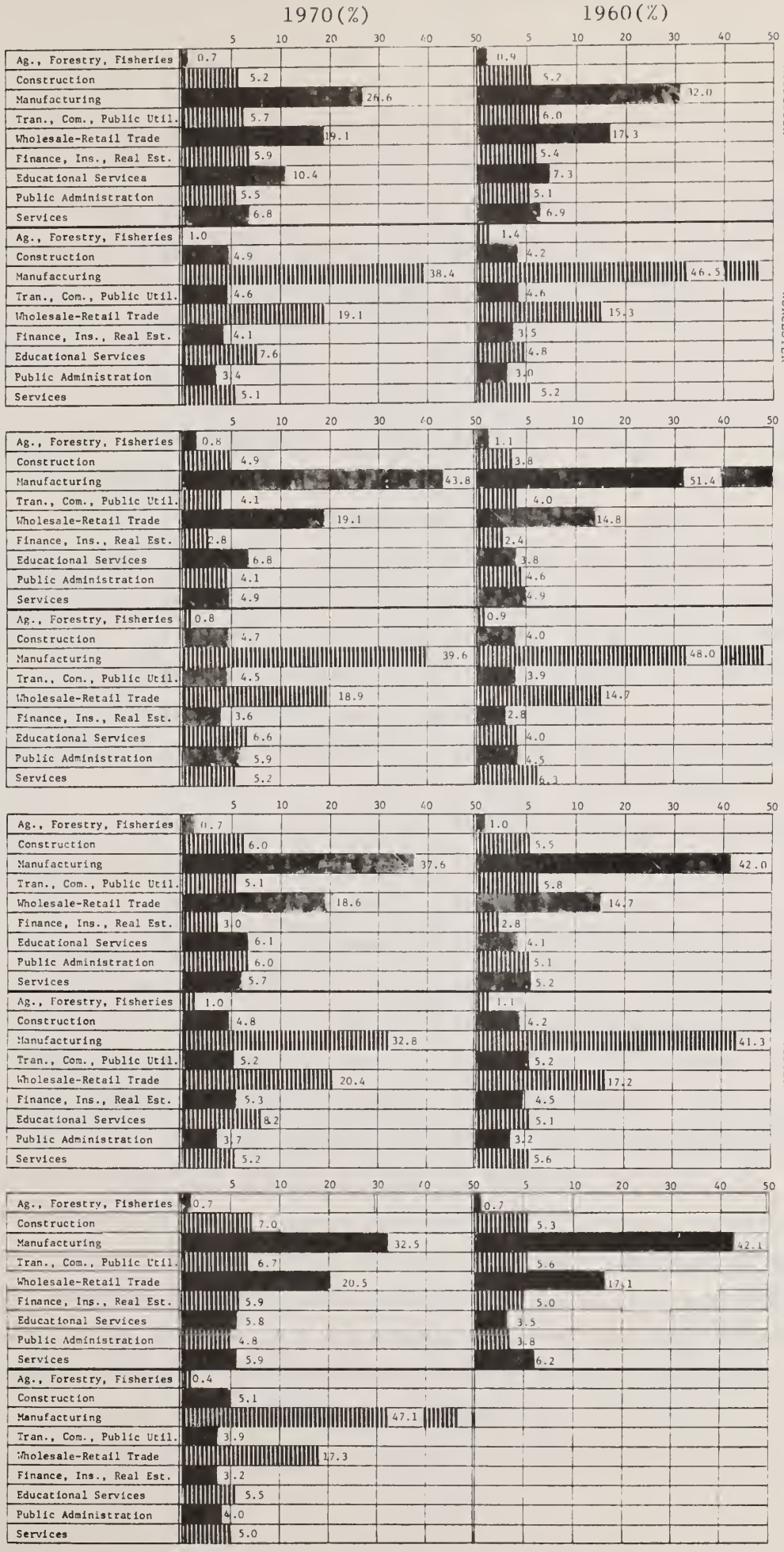


Figure 2: Percentage Distribution of Employment by Major Industries



Source: U.S. Dept of Commerce, 1960, 1972 [4002, 4003]

Fig.2 (cont'd)

Manufacturing provides the leading source of employment in the basin although it has declined relative to other occupations as a percentage of total employment. In the past, nondurable goods including textiles and leather products constituted the major products of basin industries. Lowell, Lawrence, Haverhill, Manchester and Fitchburg among others, were nationally renowned for their textile mills and apparel industries. With recent declines in these industries, the manufacture of durable goods is advancing to the lead position among sources of manufacturing employment. Major durable products manufactured within the basin include primary and fabricated metal products, machinery, and electrical equipment.

The second largest employer in the basin is the wholesale and retail trade industry. All reported jurisdictions showed the greatest increases in proportional share of total employment in the trade sector during the 1960 to 1970 period. The service oriented industries also experienced a near uniform increase in employment during the period. The strengthening of the recreational industry has significantly contributed to these gains.

Paralleling national and regional trends, agriculture, forestry, and fisheries have experienced a steady decline and in 1970 accounted for less than 1% of total employment throughout the basin.

Per capita income constitutes a measure of regional wealth and economic well-being in the basin relative to broader state and nationwide trends. Table 6 provides 1960 and 1970 per capita income averages and growth rates within the basin as compared to national and state averages. Growth rates have been adjusted to 1967 constant dollars to eliminate the effects of recent inflationary trends.

In Massachusetts, per capita income surpasses nationwide averages in all reported jurisdictions except the Lowell SMSA. Adjusted growth rates in Massachusetts vary from slightly below to considerably above the nationwide trend. If this situation remains stable, Massachusetts communities within the basin will keep pace with national growth and retain a favorable position relative to nationwide per capita income averages. In contrast, New Hampshire per capita income is below the nationwide average except in the Nashua SMSA. If the 1960-1970

Table 6: Per Capita Income

AREA	1960	%*	1970	%*	Adjusted Growth**
United States	1849	100.0	3119	100.0	28.6
Massachusetts	2052	111.0	3408	109.3	26.7
New Hampshire	1796	97.1	2985	95.7	26.8
Counties:					
Essex	2046	110.6	3430	110.0	27.9
Middlesex	2254	121.9	3738	119.8	26.5
Worcester	1881	101.7	3189	102.2	29.3
Belknap	1833	99.1	3065	98.3	27.5
Grafton	1678	90.7	3001	96.2	36.4
Hillsborough	1880	101.7	3085	98.9	25.2
Merrimack	1785	96.5	3035	97.3	29.7
Rockingham	1828	98.9	3036	97.3	26.7
SMSA's					
Fitchburg-Leominster	1697	91.8	3145	100.8	41.3
Lawrence-Haverhill	1813	98.0	3270	104.8	37.6
Lowell	1674	90.5	3008	96.4	37.0
Worcester	1882	101.8	3274	105.0	32.6
Manchester, NH	1740	94.1	2980	95.5	30.6
Nashua, NH	-	-	3244	104.0	-

Source: U.S. Dept. of Commerce Census 1960, 1970 [4003]

* % of national average
** adjusted to 1967 dollars by means of the consumer price index (CPI)

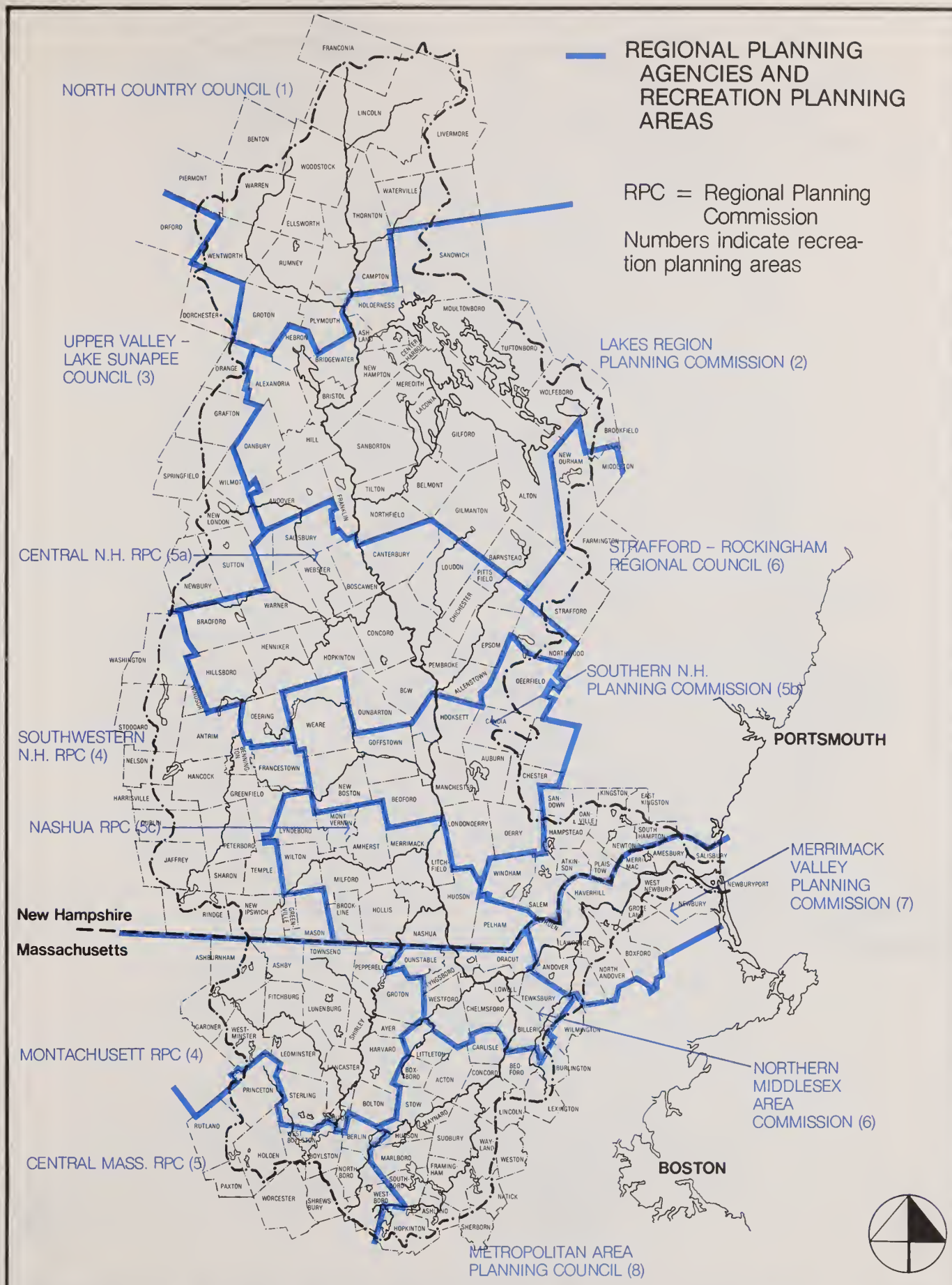
adjusted growth rates continue to prevail, New Hampshire will experience a steady increase in per capita income, but will remain below national averages.

3.2.4 Jurisdictions

The size, history of settlement and interstate nature of the Merrimack basin have lead to a complex pattern of jurisdictional divisions and a multitude of water related governmental and private programs. While existing jurisdictions and programs constitute an important dimension of conditions in the basin, a full analysis of the legal and administrative framework in which they operate is beyond the scope of this effort. Maps 9, 10 and 11 illustrate the 172 towns and cities, 11 counties, 13 regional planning agencies and other jurisdictions encompassed by the basin's boundaries and referenced throughout this report. The principal responsibilities of state, interstate and federal agencies are reviewed within each section of the water demands chapter.

3.3 SUMMARY

The natural resources of the northern Merrimack, the legacy of the industrial revolution along the main stem, and metropolitan Boston with its vast transportation system and outward growth pattern number among the most dominant forces shaping the pattern of development in the basin. Map 12 illustrates the major transportation links between urban areas within the basin as well as key basin natural resources. The pattern of rivers within the basin has clearly provided the basic structure around which urbanization and concomitant transportation systems have evolved. The following section briefly reviews major factors that have influenced development in four general areas of the basin. The areas have been selected for their commonalities in terms of physical configuration and the dominant socioeconomic influences.


REGIONAL PLANNING AGENCIES AND RECREATION PLANNING AREAS
RPC = Regional Planning Commission
Numbers indicate recreation planning areas
NORTH COUNTRY COUNCIL (1)
UPPER VALLEY – LAKE SUNAPEE COUNCIL (3)
LAKES REGION PLANNING COMMISSION (2)
CENTRAL N.H. RPC (5a)
STRAFFORD – ROCKINGHAM REGIONAL COUNCIL (6)
SOUTHERN N.H. PLANNING COMMISSION (5b)
SOUTHWESTERN N.H. RPC (4)
PORTSMOUTH
NASHUA RPC (5c)
MERRIMACK VALLEY PLANNING COMMISSION (7)
New Hampshire
Massachusetts
MONTACHUSETT RPC (4)
NORTHERN MIDDLESEX AREA COMMISSION (6)
CENTRAL MASS. RPC (5)
BOSTON
METROPOLITAN AREA PLANNING COUNCIL (8)

Regional Jurisdictions
Merrimack River Basin

0miles 5 10

BASE MAP SOURCE: USGS HYDROLOGIC UNIT MAP, 1:500,000, 1974; TOWN LINES, NERBC, 1:500,000, 1976.

9

MAP NO.

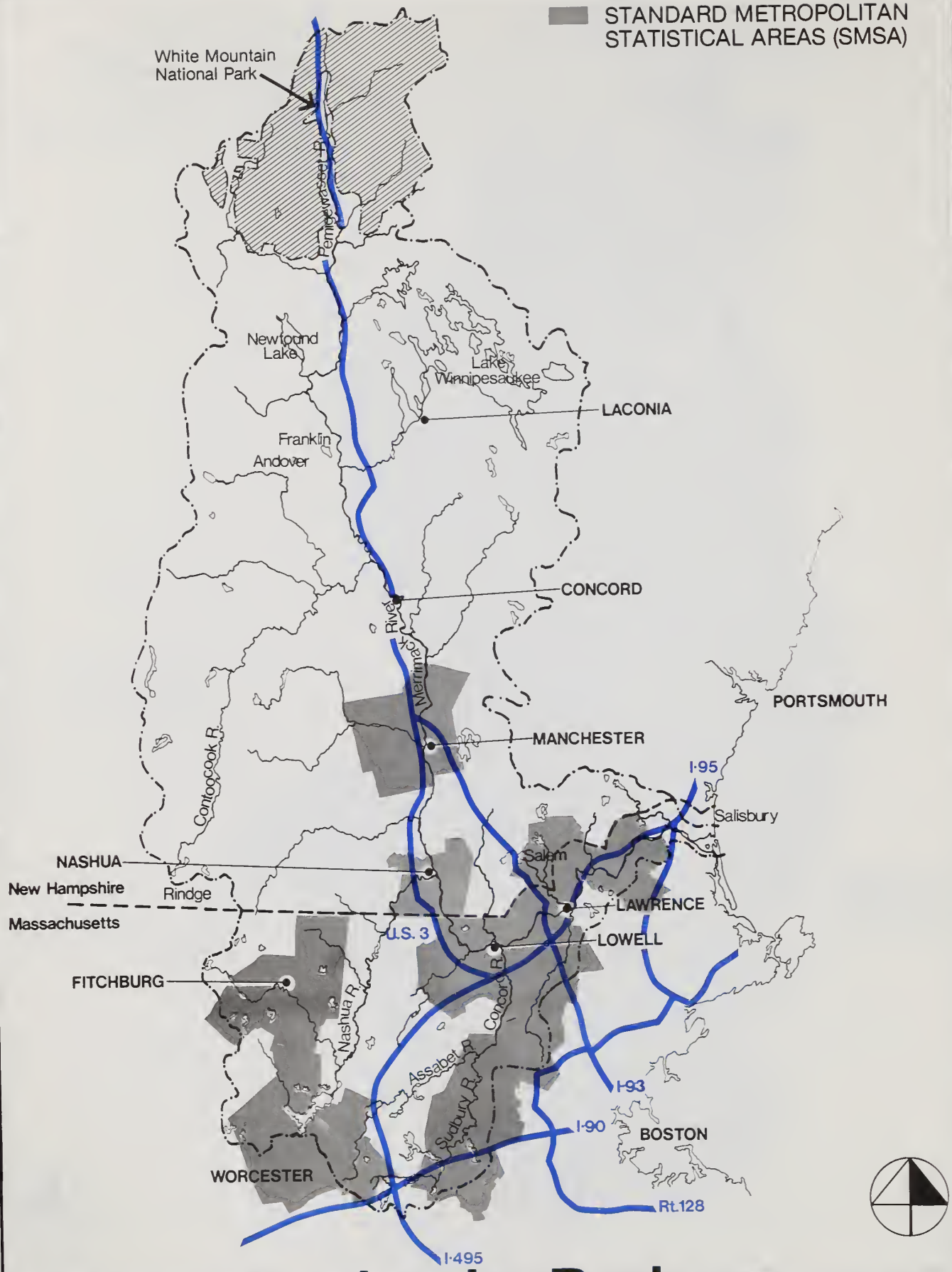
County Jurisdictions
Merrimack River Basin

0 miles 5 10

BASE MAP SOURCE: USGS HYDROLOGIC UNIT MAP, 1:500,000, 1974; TOWN LINES, NERBC, 1:500,000, 1976.

10
MAP NO.

Town Jurisdictions
Merrimack River Basin



Forces Shaping the Basin
Merrimack River Basin

0 miles 5 10

BASE MAP SOURCE: USGS HYDROLOGIC UNIT MAP,1:500,000. 1974:TOWN LINES. NERBC,1:500,000.1976.

12
MAP NO.

3.3.1 White Mountains/Lakes Region

The White Mountains and Lakes region has the most severe climate and most rugged terrain of all the Merrimack's regions. Because this area was remote from early market centers and the terrain constituted a barrier to easy access, farming has never been more than locally significant. While forestry and textile manufacturing were, in the past, the basis of this area's economy, the overall New England decline in both activities has drastically diminished their importance. Although the forest resource base remains vital, the resources which presently support the area are its waters and scenic beauty. Fully one half of New Hampshire's inland waters lie within this area. Vistas of the White Mountains, preserved in a National Forest, and the multitude of lakes support a thriving recreation industry.

The lakes themselves have attracted considerable second home and recreational development in their immediate proximity. The older population centers, Laconia and Franklin, now are service centers for the tourist industry. The White Mountain National Forest has served to channel development into linear corridors along transportation routes on adjoining non-federal land. While this area is recognized for its sensitivity to the impacts of development, its recreational potential is expected to attract continued development.

3.3.2 Central Basin (N.H.)

The central basin area, due to a slightly milder climate and the availability of fertile river valley soils, has supported a viable farm economy which continues at a diminished but still important level. The main stem and its tributaries, by virtue of hydropower potential, have developed as corridors of industry and urban development. Although the river valleys remain the most amenable development areas with the decline of the textile industry, the rivers themselves are no longer the catalysts of economic growth. The two oldest industrial centers of this area, Manchester and Concord, located along Interstate 93, maintained stable populations between 1950 and 1970 but declined in population over the 1970-1975 period. The towns around these cities are, on the other hand, growing rapidly. None of the growing towns

has particularly large populations or high density development, indicating that a dispersed pattern of development dominates this area. The slow but steady growth in the economic base of the area, if continued, can be expected to sustain this diffuse growth pattern. The implications for the recreation activity in the western part of this area are significant. Rising population will result in increased recreational demand while the diffuse settlement patterns will consume large portions of the prime recreational areas.

3.3.3 Nashua River Basin

This area retains a strong rural and early industrial character despite its proximity to Boston and Worcester. Agricultural activity remains an important part of the local economy. The original industrial centers of Fitchburg and Nashua, originally drawn by the hydropower resource of the Nashua River, now exhibit opposite patterns in growth trends. Nashua has continued to be both a center of industrial activity and population growth. Its transportation linkages with the Boston area and economic benefits of a New Hampshire location have undoubtedly contributed to its present status. Fitchburg, on the other hand, has experienced a substantial population decline over the 1950-1975 period which has become even more pronounced in the 1970-1975 period. Leominster, just to the south, has taken over Fitchburg's role as a growth center with its own ring of growing towns. Some towns in the Nashua basin are experiencing or expect development trends of a "bedroom community" nature due to the proximity to Boston, Worcester, Lowell-Lawrence, and other urban areas. With improvement in transportation (i.e. I-190), this trend should continue. While this region has grown, especially around Nashua, there are large areas of low density settlement which are expected to retain their rural character.

3.3.4 Southern Main Stem -- SuAsCo Area

This area, closest to Boston, is subject to the most complex set of socioeconomic influences of any portion of the basin. No less than 7 major highways and an extensive commuter rail service provide easy access to the Boston area. In addition, major industries are

located along this portion of the main stem in Lowell, Lawrence, and Haverhill. Extensive light industrial and commercial development occurs along Routes 128, 9 and along portions of Route 495. Interspersed among the centers of commercial and industrial development are areas of suburban development attracted by the availability of local jobs as well as the easy access to Boston.

In sorting out development patterns and the causal forces, it would appear that the influence of Boston is dominant in the SuAsCo area. It is predominantly suburban with a corridor of commercial/light industrial activity along Route 9 in the south. The area along the main stem and in southeastern New Hampshire, around Lawrence, Lowell and Haverhill, is influenced primarily by local availability of jobs although the metropolitan influence is certainly felt.

Just as this area is subject to the most complex influences, continued growth will evoke a myriad of water related problems. Non-point source pollution can be expected to continue or increase, especially in the SuAsCo basin as construction activities increase. The high population densities in this region will demand extensive systems of both water supply and wastewater treatment.

4.0 Demands Upon Basin Resources

Six major water demands and problems as well as four water related land uses are reviewed in this chapter. The approach centers on describing present conditions, plans for new uses or improvements and related local, state, and federal or private programs. Each section of the chapter concludes, as appropriate, with major findings and recommendations for future planning, data collection, feasibility studies, research, and action.

4.1 WATER SUPPLY

4.1.1 Existing Conditions: Public Water Supply Systems and Future Demands

The Merrimack River basin meets the water demands of its 1.5 million residents and an extensive industrial/commercial base, as well as the needs of several communities outside of the basin boundaries. As Map 13 illustrates, 98 towns in the basin are served by public water supplies. An estimated 80% of the basin's total population is served by these systems. Groundwater, the leading source of public water supply, is used to meet the needs of 43 communities while combined ground/surface water systems serve 25 communities and 30 communities rely on surface sources. Water is transferred from the Merrimack basin to augment the supply of the City of Worcester and the regional Metropolitan District Commission system. Lancaster, Clinton, Leominster, Northborough, Marlborough, Southborough and Framingham have joined the MDC system and withdraw water from the Quabbin Reservoir aqueduct as it passes through the basin.

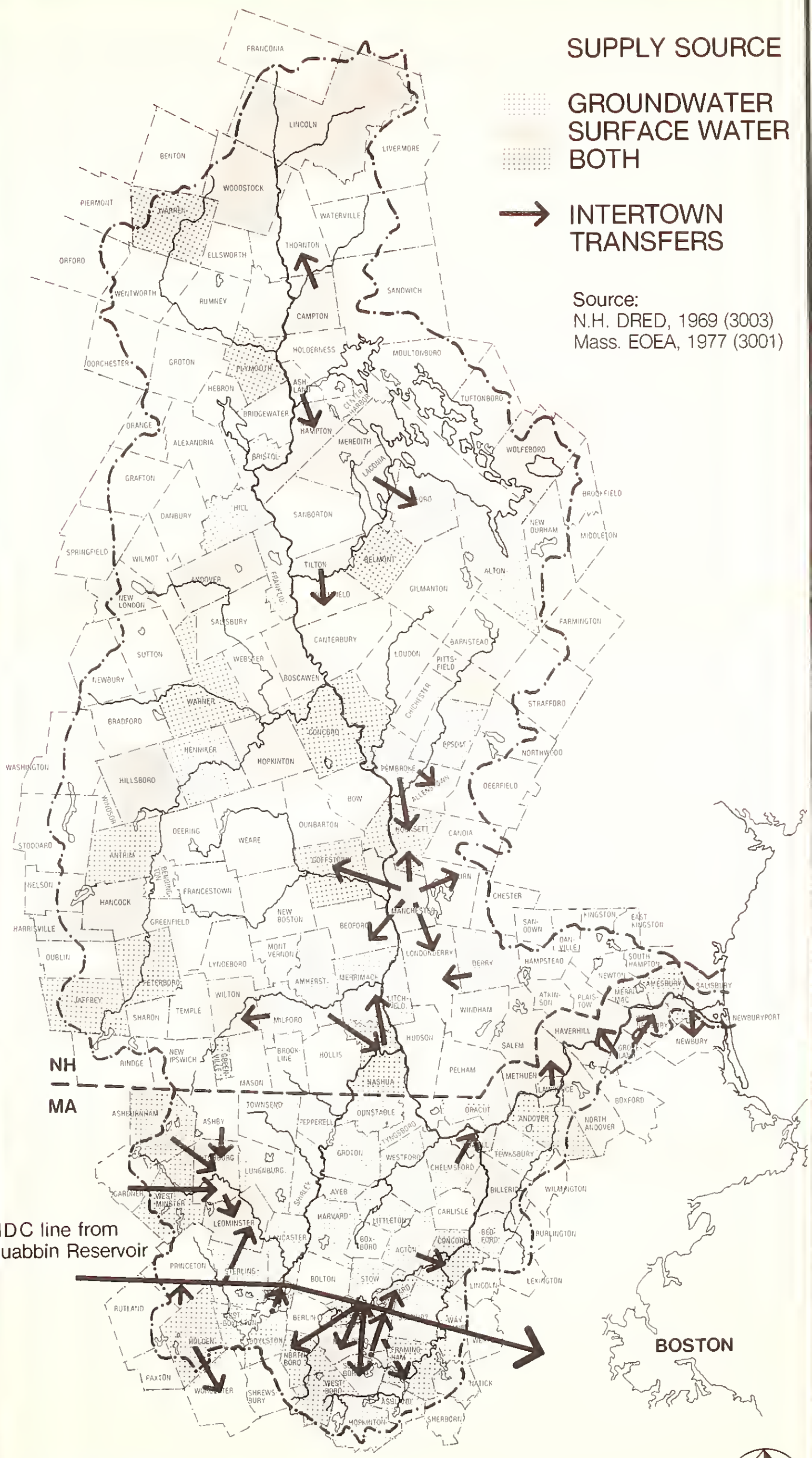
The outward growth of the Boston metropolitan area and southcentral New Hampshire's attractive atmosphere for urban, recreational, and industrial development are expected to generate increased demands for water supply in the southern half of the basin. The rise in demand will stem from the influx of new population and industrial development, as well as from anticipated increases in the average daily per capita consumption of water. Communities outside of the basin are also expected to exert demands upon the basin's water resources. Future in-basin water needs were recently assessed in conjunction with a study of the feasibility of diverting additional water from the basin to augment the regional MDC system (U.S. COE, 1977 [3009]).

Table 7 summarizes the projected water demands for 1970, 1990, and 2020 by state and the basin. This table is based on projections for communities with existing public supplies serving more than 5,000 people and thus primarily reflects the future demand situation in southcentral New Hampshire and the Massachusetts portion of the basin.

While 1970 aggregate yields will be sufficient to meet aggregate 1990 demands in the basin, localized deficiencies will occur. By 2020, an estimated 45 towns in southcentral New Hampshire and 44 towns in Massachusetts will require additional supply. Map 14 illustrates the distribution of 1990 and 2020 water demands within the basin.

In addition to the rising pressures for water among in-basin communities, the Merrimack is considered a potential supply alternative for major out-of-basin demands. Map 14 identifies the potential location of diversions discussed in the following text. As previously indicated, the Merrimack has been extensively studied by the Army Corps of Engineers as one of several alternative sources of water to augment the regional MDC system. By 2020, as much as 209 mgd could be withdrawn from the Merrimack to augment the MDC system. This project, however, is not presently planned by the MDC.

The State of New Hampshire has also considered Merrimack diversions to augment water supplies in the state's coastal region. This area offers a limited range of local supply options and is presently experiencing a rapid pattern of growth that will outstrip local supply capacities. By 1980, 14 towns in this area will require augmented supplies and by 2020, 29 towns will need additional supplies (U.S. COE, 1976 [3008]). The



Public Water Supply
Merrimack River Basin

Omiles 5 10

BASE MAP SOURCE:
USGS HYDROLOGIC UNIT MAP, 1:500,000
1974; TOWN LINES,
NERBC, 1:500,000, 1978

13
MAP NO

Table 7: Projected Water Demands

Municipal System	1970 Present[1] Dependable Yield	1970 Average Demand	1990 Average Demand	2020 Average Demand
Massachusetts				
Acton	2.75	1.08	2.80	5.53
Amesbury	3.00	0.97	1.79	2.63
Andover	14.50	3.20	7.10	10.90
Ashland	4.36	1.33	2.69	5.08
Ayer	1.50	0.85	1.24	1.84
Bedford	3.30	1.58	3.03	3.41
Billerica	14.00	2.65	5.60	7.30
Chelmsford	5.80	2.36	5.56	7.06
Clinton[2]	N/A[3]	0.86	3.23	4.14
Concord	5.50	1.78	3.36	6.36
Dracut	2.70	1.06	2.79	3.90
Fitchburg	11.90	7.90	10.83	14.46
Framingham[2]	2.13	7.15	10.83	15.26
Groton	1.51	0.82	1.39	2.95
Groveland	1.30	0.55	1.37	1.98
Haverhill	8.75	6.20	9.70	12.60
Holden	1.02	1.26	2.23	3.58
Hopkinton	1.30	0.45	1.02	2.93
Hudson	2.52	1.35	3.56	5.66
Lancaster[2]	1.00	0.49	0.74	1.49
Lawrence	14.00	10.00	9.04	11.51
Leominster[1,2]	7.25	8.07	12.04	16.56
Littleton	1.80	0.66	1.82	3.75
Lowell	10.50	10.00	13.09	16.42
Lunenburg	0.75	0.28	0.61	1.60
Marlborough[2]	5.53	2.41	3.57	5.51
Maynard	1.04	0.75	2.30	3.20
Methuen	N/A[4]	2.80	4.93	6.23
Natick	10.16	6.50	7.58	10.33
Newburyport	3.35	2.15	3.25	5.27
North Andover	3.00	1.88	3.70	5.30
Northborough[2]	0.95	0.70	1.75	2.94
Pepperell	1.70	0.54	2.17	4.52
Shrewsbury	2.90	1.60	2.69	4.29
Southborough[2]	N/A[3]	0.44	0.88	2.05
Sudbury	3.70	1.12	3.19	6.08
Tewksbury	3.30	1.87	4.14	5.14
Wayland	5.58	1.58	3.22	5.87
Westborough	1.99	1.01	2.31	3.70
West Boylston	2.05	0.48	0.85	1.42
Westford	4.80	0.62	2.96	3.96
TOTALS	173.24	99.35	166.95	244.71
New Hampshire				
Bedford	N/A[5]	1.10	3.60	11.50
Concord	4.40	4.10	6.70	13.20
Derry	0.60	0.37	3.30	10.20
Franklin	3.00	0.75	1.20	2.60
Goffstown	N/A[5]	1.15	4.60	12.00
Hooksett	N/A[5]	1.50	2.70	6.80
Hudson	1.75	0.50	2.80	8.50
Laconia	7.63	1.30	1.90	2.80
Londonderry	N/A[5]	0.73	3.70	20.00
Manchester	22.00	13.97	14.50	16.00
Merrimack	5.18	0.74	4.00	12.00
Milford	1.92	0.64	1.40	2.80
Nashua	13.70	9.55	10.00	13.00
Salem	2.25	0.97	5.40	7.80
TOTALS	62.43	37.37	65.80	139.20
GRAND TOTALS	235.67	136.72	232.75	383.91

[1] In communities served only by wells, capacity must be available to meet maximum daily demands

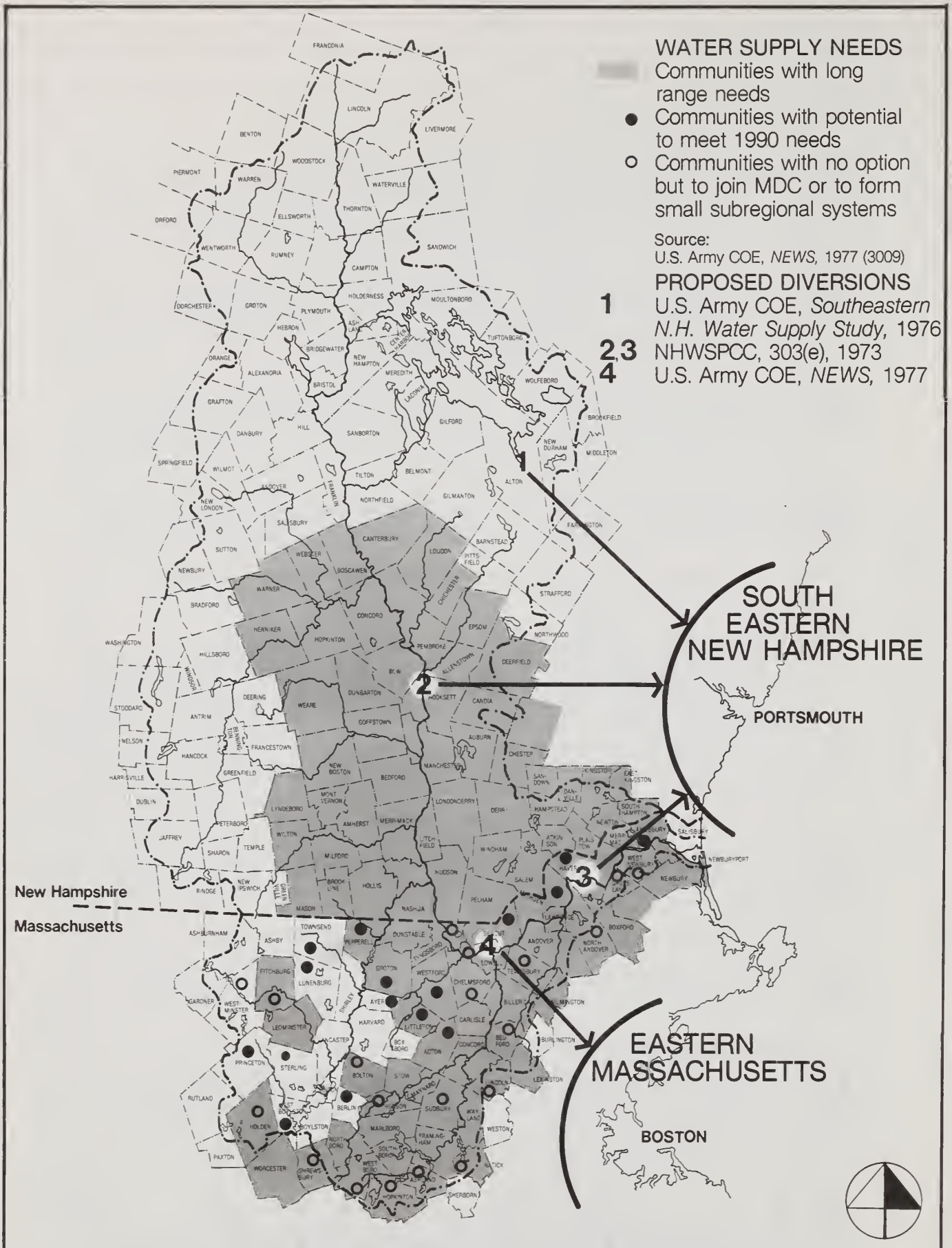
[2] Receive a portion of supplies from MDC

[3] Water available as needed by community as part of an agreement with the MDC

[4] Receives water from Lawrence

[5] Receives water from Manchester

Source: U.S. COE, [3009]



Water Supply Needs
Merrimack River Basin

0 miles 5 10

BASE MAP SOURCE: USGS HYDROLOGIC UNIT MAP, 1:500,000, 1974; TOWN LINES, NERBC, 1:500,000, 1976.

14
MAP NO.

potential also exists for the development of an oil refinery complex in the coastal area. A major refinery could use as much as 10 mgd which would far exceed local supply capacities of the coastal communities. The Merrimack thus offers an attractive alternative for water supply in this area.

Water use figures have been developed sporadically in the basin in conjunction with local and substate, regional water supply plans. Available figures do not cover the entire basin nor are they reported for standard base years in accord with uniform use categories. Thus a summary of aggregate water use cannot be developed for the basin. Table 8 presents water use estimates for the two states, and two adjoining regions as general indicators of probable use within the basin.

Use estimates vary considerably among the three reports, reflecting variation in survey approach as well as differences in the character of the surveyed areas. Only limited commonalities in the estimates can be expected to apply to water use in the basin.

Domestic demands, for example, can be expected to constitute the leading use of publicly supplied water in the basin. Likewise, industry is probably the second largest demand on public water supply but the leading user of all water in the basin. Many water dependent industries in the basin are known self-suppliers of large but unquantified amounts of water. Statewide estimates of self-supplied industrial water use are considered comparable to the situation in the Merrimack basin. In Massachusetts, industries self-supplied 1,130 mgd in 1970, while in New Hampshire 440 mgd were developed and used by industries. These amounts constitute 1.5 and 6 times the amount of total public water supply in Massachusetts and New Hampshire, respectively.

Suspected, though unquantified, losses of water are recorded in the unmetered category of the MDC and Eastern Massachusetts surveys. Considerable potable water may be lost annually through leaks in the aging distribution systems that serve many of the region's old urban centers. It is expected that this problem is shared by many of the communities in the Merrimack. Rehabilitation of these systems will constitute a major financial burden for the towns and states involved.

TABLE 8

WATER USE ESTIMATES

Water Use:	MDC[1] Service Area		Eastern[2] Massachusetts Study Area		USGS Statewide Survey[2]			
	mgd	%	mgd	%	mgd	%	mgd	%
Total	376.7	100	163.4	100	760	100	70	100
Industrial	50.0	13.2	38.0	23.3	N/A	N/A	N/A	N/A
Commercial	43.8	11.5	10.6	6.5	N/A	N/A	N/A	N/A
Combined	93.8	24.7	48.6	29.8	320	42.1	22	31.4
Domestic	125.6	33.3	100.4	61.4	N/A	N/A	N/A	N/A
Public	25.8	7.0	3.8	2.3	N/A	N/A	N/A	N/A
Unmetered	131.5	35.0	10.6	6.5	N/A	N/A	N/A	N/A
Combined	282.9	65.3	114.8	70.2	440	57.9	48	68.6

N/A - not available

Sources:

1. Water Resources Research Center, Univ. of Mass., Water Usage Studies in Communities Served by the Metropolitan District Commission, Curran Associates, 1975 [3011]

2. U.S. Army Corps of Engineers, New England Division, NEWS Merrimack River Basin Water Supply Study, Water Demand Study Eastern Massachusetts Region, Coffin & Richardson Inc., November 1974 [3005]

3. United States Geological Survey, Estimated Use of Water in the United States in 1970, Circular 676, 1970 [3010]

The absence of uniform water use statistics and the consequent inability to make accurate projections is a barrier to effective water supply planning, for the Merrimack as well as other regions. The NEWS study, as well as the recent Massachusetts Water Policy study recommend the adoption of uniform water use reporting procedures for use by local water suppliers in their annual operating reports. Action towards this end, along with continued efforts to fill gaps in the present state reports on existing public water supply systems, would greatly enhance the water supply planning process.

4.1.2 Plans and Programs

Since the 7-year drought of the early 1960s, many of the towns, most of the regional planning agencies, both states and several federal agencies have developed water supply plans and studies dealing with the Merrimack basin. The following summarizes existing and proposed planning efforts of basinwide consequence.

In 1972, New Hampshire completed a statewide survey of public water supply designed to assess long-range water demands and supply alternatives (NH OCP, 1972 [3004]). The study determined that towns in the northern half of the basin and along the basin's western boundary could meet future demands with small independent town supply systems. In the southern half of the basin, the cities of Concord, Manchester, and Nashua and their environs were identified as major growth centers that would soon achieve population densities warranting the development of major new supply systems.

The preliminary recommendations of the state water supply plan have been modified by more recent state planning reports. In southcentral New Hampshire, three regional systems have been proposed. Concord, Manchester and Nashua would develop supply systems with capacities to serve 16, 8, and 17 towns, respectively. Two alternatives to the Alton Bay diversion for the coastal region, proposed by the original plan, have also been advanced. Both would divert water from the Merrimack main stem either at Hooksett, or above tidewater in Massachusetts (see Map 14) (NH WSPCC, 1973 [3116]).

The State of New Hampshire and the Corps of Engineers are scheduled to conduct further investigations of the water supply requirements for

southeastern New Hamsphire. The study building on the Southeast New Hampshire Water Supply Study (COE, 1976 [3008]) will emphasize local supply options including reservoir development and water conservation. The study is also expected to assess the need for diversions from the Merrimack basin to the coastal areas as a source of last resort.

The Corps of Engineers study of potential Merrimack diversions is the most recent plan dealing with basinwide water supply issues (U.S. COE, 1977 [3009]). As previously mentioned, the study assessed in-basin needs through 2020 in connection with possible out-of-basin diversions to the eastern Massachusetts region. The Merrimack is one of five major alternatives being considered by the Corps. The study concluded that the Merrimack could be tapped for an estimated 209 mgd by 2020. Alternatives considered include high flow skimming during seasonal peak runoff or continuous withdrawals with low flow augmentation reservoirs developed upstream in New Hampshire. The study further identified reactivation of the Upper Sudbury Reservoir System as a short-term measure to augment present MDC supplies. This option is presently under study by the MDC. An analysis of demand reduction methods concluded that water conservation efforts could make significant contributions to the area's water supply picture.

In Massachusetts, the most recent water supply planning effort has focused on developing policies to provide the framework for more intensive yet flexible project planning to meet state water supply needs through 2020. (Mass. EOEA, 1977 [3001]). Although no specific Merrimack diversions are under study in Massachusetts, the water policy study advances recommended policies that will have implications for any future interbasin transfers in the state. For example, maintenance of basin integrity is recommended as a statewide priority. However, where in-basin supply options are exhausted or inadequate to meet future needs, the study recognizes that interbasin transfers may be the only alternative. The study, in making extensive recommendations for water conservation efforts, has also stimulated statewide interest in water conservation practices which may have the long-term effect of mitigating the need for the Merrimack diversion to the eastern Massachusetts region. Proposals to encourage water conservation in public supply systems are currently before the Massachusetts Legislature. In addition to basic policy recommendations, the study suggests organizational

changes to enhance state water planning and monitoring capabilities. In a related vein, the MDC has undertaken an effort to improve the metering of its water distribution system and is also attempting to devise a rehabilitation program for its member towns.

The U.S. Department of Agriculture and the Massachusetts Water Resources Commission are conducting a statewide study of water and related land resources within the Commonwealth. The study is designed to identify problems, needs and alternative solutions with respect to land use, flooding, erosion and sediment, recreation, fish and wildlife, wetlands, water supply and water quality. The Merrimack basin is included in two broader reporting regions within the context of this study and is scheduled for completion in 1978. Completed elements of the study of importance to the Merrimack are existing and potential reservoir site surveys covering the entire drainage area in Massachusetts. The Forest Service, Economic Research Service and the Soil Conservation Service are the United States Department of Agriculture (USDA) agencies participating in this study. The Massachusetts Division of Water Resources, the Massachusetts Division of Fisheries & Wildlife, the Massachusetts Division of Forests & Parks, and the Massachusetts Division of Water Pollution Control are the state agencies most actively involved.

An additional component of Massachusetts' water resources planning is a cooperative effort with USGS to inventory the state's groundwater resources. This project is designed to fill a gap in the knowledge of groundwater systems which is characteristic of the entire basin. Although surface waters have been extensively surveyed and monitored, comparable analysis of groundwater has yet to occur. The completed and ongoing USGS and RPA studies in New Hampshire and Massachusetts will provide reconnaissance level information concerning the location and probable yield of aquifers. These studies should provide the groundwork for more extensive analysis of groundwater quantities and of the interaction between surface flows and groundwater.

Program responsibilities for planning, financing, developing and maintaining public water supplies are distributed among local, state, federal, and private agencies. The following summarizes the principal responsibilities fulfilled by each of these entities.

Local/Private. The development of water supplies is a traditional responsibility of local jurisdictions. This includes the preparation of plans, acquisition of financing, construction, and ultimately the maintenance and protection of supply systems. The local approach to water supply planning varies with available financial resources. Most larger towns have independently developed water supply plans, while smaller communities rely heavily on the assistance of regional planning agencies. Communities in both states may rely on three alternative types of supply development entities including municipal water departments, special water districts or precincts, and private water companies.

Towns are also responsible for regulating private wells through the issuance of building permits and local board of health permits, and in some instances enforce state statutes prohibiting the installation of septic tanks within 100 feet of water supply wells through subdivision regulation.

States. State agencies approve the construction of new or expansion of existing public water supplies including the sources of water, methods of treatment, and means of distributing water. In New Hampshire, the Water Supply and Pollution Control Commission (WSPCC) fulfills these responsibilities, while in Massachusetts they are distributed between the Department of Environmental Quality Engineering and the Department of Environmental Management. Both states are authorized to develop statewide water supply plans and offer limited technical assistance in the identification and development of local sources of water. Massachusetts is authorized under Chapter 21, Sec. 9a to aquire water impoundment sites to meet future water supply needs. Based on the federal Safe Drinking Water Act of 1974, both states have established new standards for drinking water quality and procedures for monitoring compliance with the more stringent requirements.

Federal. The federal role in water supply development includes finance, planning and regulation. The three principal agencies offering financial assistance for the development of water supply are the Economic Development Administration, Farmers' Home Administration, and the Department of Housing and Urban Development. However, supply development is generally secondary to the central purposes of the programs these agencies administer, and eligibility requirements for community participation have limited their application in the basin. Major federal planning responsi-

bilities include the development of basic data, coordination, and in the case of the Merrimack, direct responsibility for developing a water supply plan under the auspices of PL 89-298 which authorized the Northeastern United States Water Supply Study.

Federal regulatory responsibility stems from the Safe Drinking Water Act of 1974 (PL 93-523) which is administered by the Environmental Protection Agency. Under the authority of this act, EPA has conducted extensive monitoring programs as a basis for promulgating drinking water quality standards which will be enforced by designated state agencies. The best known of the monitoring programs is the National Organics Monitoring Survey (NOMS) which is designed to identify the presence of harmful organic compounds such as the trihalomethane group (THM, a carcinogenic agent formed during the chlorination process). THMs were found in all 113 of the water supply systems monitored nationwide in 1976 including those at Manchester, New Hamsphire, Lowell and Lawrence, Massachusetts. As a result of the NOMS, regulations are being developed for the concentrations and monitoring of various organic compounds in drinking water. Interim regulations have also been promulgated for several inorganic substances.

4.1.3 Findings and Recommendations

Planning. The major planning problem in the Merrimack stems from the need to balance future water supply development with other water demands including, among others, hydropower development, recreation, restoration of anadromous fisheries, and maintenance of water quality. This problem may be complicated by the possibilities of major out-of-basin diversions and the controversy that will inevitably surround such development. Major uncertainties with respect to the Merrimack River basin diversions include:

- the magnitude of the possible diversions and the degree to which in-basin water supply and other demands will be preempted by their development;
- the possibility of allaying the need for diversions by reducing out-of-basin demands through aggressive conservation practices, rehabilitation of antiquated distribtuion systems, or developing local water resources;
- the anticipation and mitigation of all adverse consequences.

The several water supply plans advanced for the Merrimack have not provided the basis for balancing competing demands or resolving uncertainties with respect to the diversions. This situation stems from variations in planning methods, differences in projected water demands and reported system capacities, and ultimately, differences in recommended solutions for meeting future basin demands.

Massachusetts and New Hampshire have been advised through their respective state water supply plan reports to assume water supply planning as an ongoing function of state government. The plans further recommend that water supply planning and development be conducted within the context of a broader water resources management program. Specific recommendations as to modifications in existing state planning agencies are embodied in the state plan reports and are not reiterated here. General characteristics of the recommended approach include:

- continued monitoring and the development of uniform reporting procedures on existing public water supply systems and their annual operating characteristics;
- the development and adoption of a standard water demand prediction methodology for use by all federal, state, regional and local water planning agencies;
- detailed evaluation of all water supply alternatives with conservation practices and groundwater sources given precedence over other alternatives whenever possible;
- identification of the consequences of supply projects, particularly as they relate to surface flows and aquifer recharging, as well as other water uses;
- an effective process for balancing the development of water supply against other important demands upon the basin's water resources; and
- coordination of related planning activities among state agencies.

The Massachusetts Executive Office of Environmental Affairs and the New Hampshire Water Supply and Pollution Control Commission are encouraged to adopt the recommended approach to state water supply planning.

Although the out-of-basin diversions are uncertain possibilities at present, both states should be prepared to participate in advanced planning for the activation of either Merrimack diversion. In anticipation of the controversy that will accompany any diversion project, a special approach to additional planning based on joint state agreement should be adopted. *Planning based upon the principles of arbitration is recommended. Within the context of this approach, the planning process is open to the public and phased to develop full consensus among all interests as to the validity of each step in the process. While controversy will be inevitable, this process will dispense with conflicts over the vailidity of basic data, demand projections, analysis of alternatives, and consequences of the selected project. In so doing, it will expedite and aid in the final decision making process.*

While the Army Corps of Engineers may conduct the technical investigations associated with future diversions, Massachusetts and New Hampshire should assume joint responsibility for study direction. *Formal agreements as to the means of establishing this interstate relationship should receive early consideration in preparations for further investigation of the diversions. The NERBC should provide the vehicle for coordinating state and federal action towards this end.*

Data Collection. Future data needs will vary with the selected approach to uniform statewide water supply planning. Standards for base years, period of projections, and parameters used to describe existing and future conditions should be developed within the context of the uniform approach. However, existing gaps in the information base can, in many instances, be immediately filled, as has been indicated in the states' water supply planning reports. The following recommendations provide the basis for more accurately assessing present supply capacities, and for developing better projections of future water demands. They also identify local resource potentials for meeting future demands, thus facilitating local protection of future supply options. It is recommended that:

- *the states and the U.S. EPA expedite the ongoing survey of existing public water supply systems. In conjunction with this effort, localities should be required to report the distribution of water among a uniform set of major consumers, including industry, commercial, residential, and municipal;*

- *the states, designated 208 agencies, and USGS should coordinate ongoing groundwater surveys and mount additional studies necessary to evaluate the groundwater as a source of supply in the southern half of the basin; and*
- *the New Hampshire Water Resources Board should initiate reservoir site studies in the southern half of the state.*

Feasibility Study. It is recommended that, in an effort to reduce uncertainties with respect to the Merrimack-Coastal diversions, the proposed New Hamsphire and Corps of Engineers study of water supply in southeastern New Hamsphire should:

- *exhaustively examine local sources of potable water prior to considering a Merrimack diversion;*
- *assess the possibility of applying conservation practices to reduce coastal water demands; and*
- *fully consider the Merrimack basin's public water supply needs along with other water demands in the context of any proposed diversion of Merrimack water.*

Action. Beyond the broad problems and needs with respect to water supply planning, the construction and maintenance of supply systems constitutes a major burden on local financial resources. Many systems within the basin are old and expensive to maintain. Rehabilitation of existing systems and construction of new systems will be required in many parts of the basin to meet future demands. Safeguarding existing supply watersheds against public health hazards while attempting to reserve additional watersheds for future supply options is another dimension of the local financial problem. The more stringent standards for drinking water quality and allied monitoring requirements embodied in the Safe Drinking Water Act of 1974 (PL 93-523) add to the costs of local water supply systems.

Several proposals have been advanced in existing plans for the development of large multitown regional supply systems. A major justification for the advancement of these proposals is the potential to reduce local water supply costs through large system economies of scale. Barriers to the development of regional systems include the strong sense of local home

rule and self-sufficiency within basin communities. Regional systems are thus infeasible in many instances where they offer the most efficient supply alternative.

Neither Massachusetts nor New Hampshire offer financial assistance in the development of local water supply systems. While several federal programs provide loans and grants to communities, water supply is generally secondary to the central purpose of these programs. In programs directly geared to water supply development, eligibility requirements limit their applicability basinwide.

In view of the local financial burden and potential economies of scale in multitown regional systems, it is recommended that:

- *new federal loans and grants be developed to support local water supply development projects; and*
- *conditional federal grants and loans be considered as a means of providing added incentives for the development of multitown regional systems.*

Rehabilitation of existing water treatment and distribution systems may increase available water supply within the basin by recovering water lost through system leaks. It is recommended that:

- *federal grants should be made available for system surveys and engineering reports on rehabilitation opportunities and requirements within existing water supply systems; and*
- *federal loans and grants should be made available for rehabilitation projects where the recovery of leakage offers significant potential to increase available water supply.*

Future demands for water supply may be reduced through the implementation of aggressive water conservation practices. It is recommended that:

- *the New Hampshire Water Supply and Pollution Control Commission and the Massachusetts Executive Office of Environmental Affairs should encourage basin communities to implement water conservation practices as a means of reducing future water demands.*

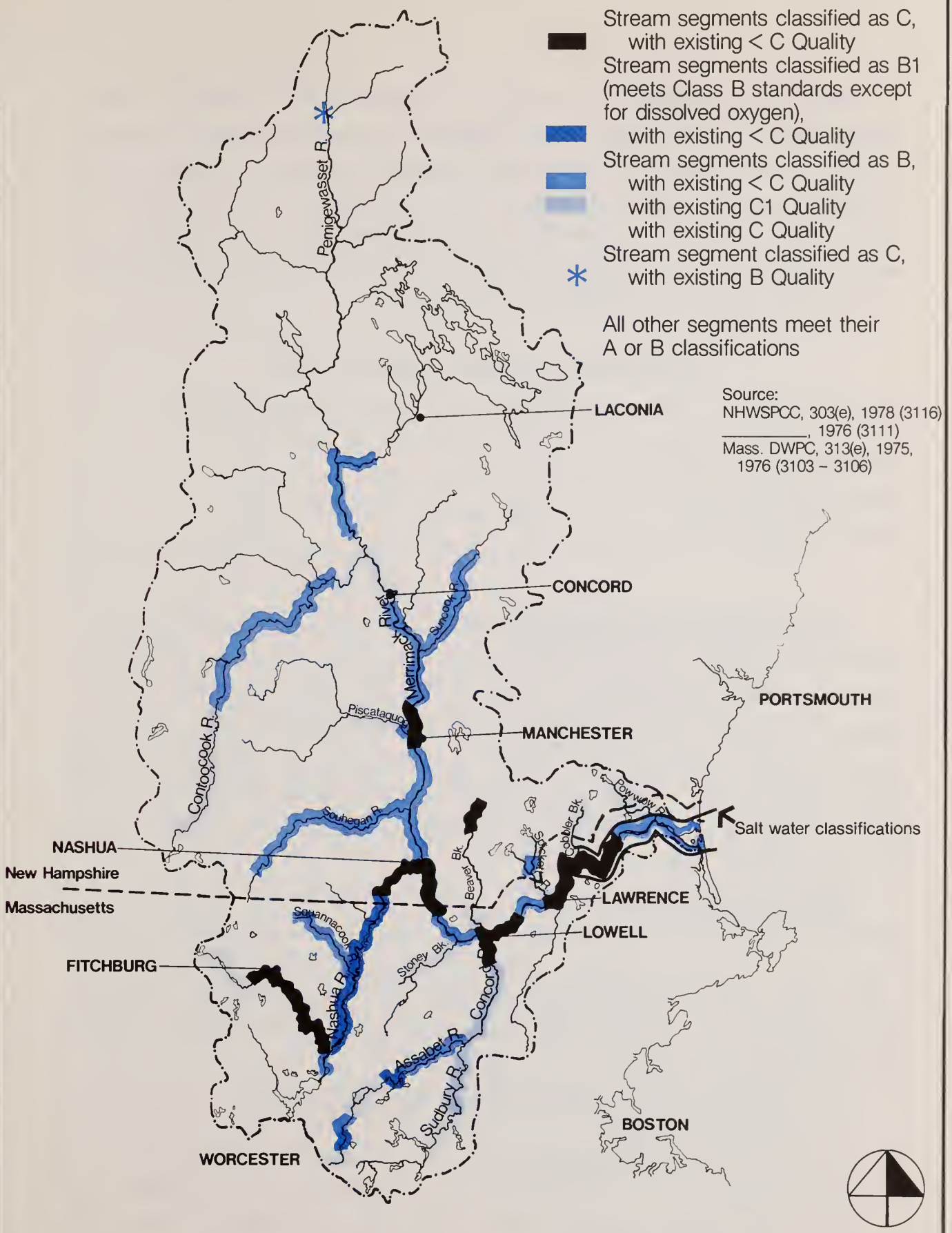
The increased commitment of the states to water supply planning within broader water resources management programs will require additional funding. The states may utilize annual grants from the Water Resources Planning Act to establish and maintain the recommended approach. An increased federal share in the states' costs as an incentive for the development of comprehensive water resource management programs is warranted. It is recommended that:

- *the federal cost share in state water resources planning and management be increased; and*
- *additional federal grants be conditional based on specific requirements establishing a mandatory but flexible approach to developing state water resources policies, plans and management programs.*

4.2 WATER QUALITY

4.2.1 Existing Conditions: Water Quality Problems

The Merrimack has long been recognized as one of the most seriously polluted rivers in New England. Major problems originated in the 1800s with the discharge of wastes from the developing leather, textile, and paper industries. The legacy remains, for example, in the Nashua River where most contributing discharges have been treated but the river continues to send 100 year old industrial sludge to the surface. Given the historical patterns of pollution discharges, coupled with continued domestic wastewater treatment needs, it is not surprising that the pollution abatement efforts of the last two decades have been less than 100% successful in meeting the 1983 goal of Class B fishable/swimmable water. It is is anticipated that 113 river miles, or 14% of the basin's major navigable rivers, will not meet the Class B standards mandated by the Clean Water Act (PL 92-500 as amended) (U.S. EPA, 1976 [3115]). These segments are shown in Map 15, as are those recently classified as Class C, unsuitable for bathing and water contact recreation. The discrepancies between existing and proposed quality are explained by the following factors.



Existing Water Quality
Merrimack River Basin

0miles 5 10

BASE MAP SOURCE:
USGS HYDROLOGIC UNIT MAP, 1:500,000, 1974; TOWN LINES, NERBC, 1:500,000, 1976.

15
MAP NO.

Municipal discharges. Industrial and domestic waste constitute the largest and most serious pollutant loadings in the basin. Most are being treated through municipal wastewater treatment facilities. However, inadequately treated industrial and municipal wastes are still being discharged due to delays in municipal facilities construction at Lowell, Nashua, and Ayer, and by facility operation and maintenance problems, as occur at the Fitchburg Westerly and Ayer plants.

Point Source Discharges - Flow in MGD

River Segment	Municipal/Sanitary	Industrial
Merrimack River, NH	38.3	7.0
Nashua River	21	19.9
Merrimack River, MA	31.5	22.2

(Abt Assoc. 1975 [3101])

Combined storm and sanitary sewers. Overflows from combined sewers have created water quality problems downstream of major main stem communities and the Fitchburg/Leominster area on the Nashua (see Map 16). The expense of correction and sporadic nature of the problem have resulted in a lower priority for solution in most areas. It is expected that combined sewer overflows and related urban runoff will be the most significant long-term problem and will, in fact, be the major factor preventing achievement of 1983 Class B goals in the basin.

Nonpoint source (NPS) pollution. The contribution of nonpoint or diffuse source pollution to water quality problems has been masked by the more significant point sources. However, nonpoint sources have been identified through 208 and 303(e) planning programs. The 208 project conducted by the Lakes Region Planning Commission (LRPC) has ranked a series of nonpoint sources as follows:

(1) malfunctioning subsurface waste disposal systems
(2) stormwater runoff
(3) erosion and sedimentation
(4) boating
(5) solid waste disposal
(6) septage disposal

(7) forest practices

(8) road salt

LRPC further suggested that various land use controls offer the most cost effective means of safeguarding water quality in major portions of the lakes region. More extensive analysis of NPS pollution will become available as the 208 plans are finalized. (See discussion of 208 planning and Table 10.)

Lake eutrophication. Acceleration of lake eutrophication stemming from both point discharges and NPS pollution is a basinwide problem. Nineteen or 6.4% of the 297 lakes and ponds greater than 20 acres in the Merrimack basin in New Hampshire are classified as eutrophic. In Massachusetts, of the approximately 30 lakes surveyed in the Merrimack and SuAsCo subbasins, most are shallow, have moderate to dense aquatic vegetation, and some algal problems. Lakes surveyed in the Nashua subbasin have not yet been classified by eutrophic condition, but are generally deeper and less susceptible to eutrophication.

Discharges from municipal wastewater treatment facilities have resulted in low dissolved oxygen levels, aquatic nuisances, and algal blooms in Lakes Winnisquam, Kezar, and certain bays of Lake Winnipesaukee in New Hampshire, and in the run-of-river lakes in the Nashua and SuAsCo subbasins in Massachusetts. The policies of both states to allow no new point discharges of nutrients into lakes or contributing streams, and to treat existing discharges to the extent technically feasible should be effective means of eliminating point source problems. The response to these policies in the Lakes Region of New Hampshire has been to transfer municipal wastes to a regional facility at Franklin on the Merrimack River as part of the Winnipesaukee Basin Project.

Limited capacity of receiving waters to assimilate wastes. The location of major polluters on the high flow main stem was fortuitous in terms of water quality. Lesser discharges to lower or slower flowing streams, as for example the Concord, Assabet, and Sudbury, have created water quality problems that equal those on the main stem. Significant but localized problems have been created on Beaver Brook, the Spickett River, Cobbler Brook, and Black Rock Creek by municipal discharges from Derry, Salem, Merrimac, and Salisbury, respectively. On both the Nashua and Assabet Rivers, slow flows in conjunction with a continuous

series of discharges have resulted in below Class C water quality. Even as advanced waste treatment facilities, transhipment, and land disposal are instituted to meet water quality goals for these rivers, the need to maintain river quality will limit future increases in instream discharges.

4.2.2 Plans and Programs

As early as the 1830s, the water quality of the Merrimack River has been the focus of a series of special planning studies. Major recent studies and cooperators include:

- 1960s Merrimack River Project
  Federal Water Pollution Control Agency, Massachusetts and New Hampshire

- 1971-76 Nashua River Program
  New England Regional Commission, New England Interstate Water Pollution Control Commission, NERBC, Massachusetts and New Hampshire [3102]

- 1972-76 Merrimack Wastewater Management Study - Key to a Clean River
  U.S. Army Corps of Engineers (COE), U.S. Environmental Protection Agency (EPA), Massachusetts and main stem regional planning agencies (RPAs) [3113]

  Boston Harbor - Eastern Mass. Metropolitan Area EMMA Study
  Metropolitan District Commission (MDC), COE, [3107]

Beyond these multiagency, often interstate efforts, the Massachusetts Division of Water Pollution Control (Mass. DWPC), Department of Environmental Quality Engineering (Mass. DEQE), and the New Hampshire Water Supply and Pollution Control Commission (NHWSPCC) have initiated planning programs under Sections 201, 208 and 303(e) of the Clean Water Act (PL 92-500).

303(e) basin plans. Both states have developed water quality management plans for the basin as part of their continuing planning process. These plans establish water quality goals and abatement needs and are coordinated with the other water quality planning, regulatory, and funding programs. Both states are in the process of revising the basin plans to reflect the 1983 goals established by PL 92-500.

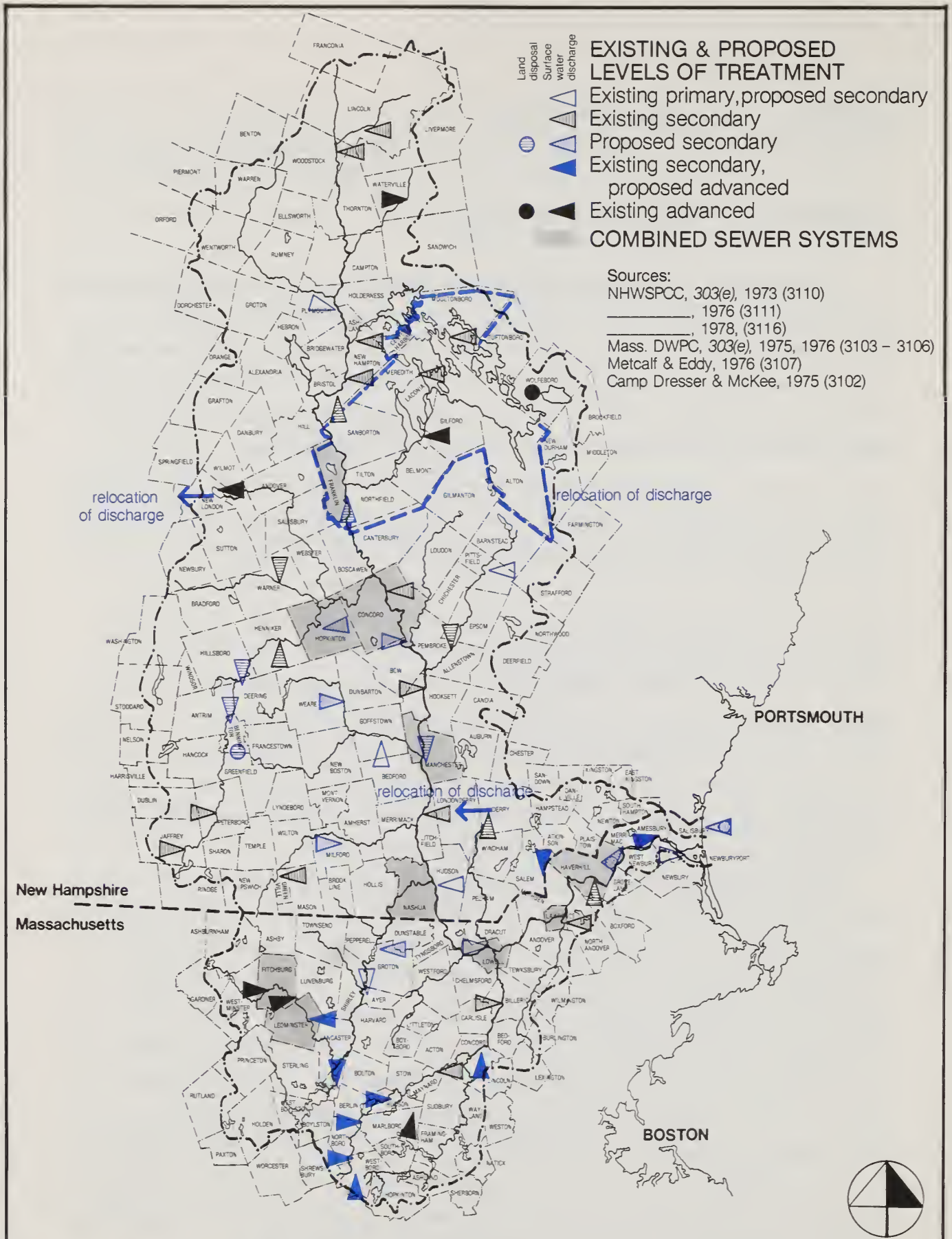
AUTHOR	BASIN	DATE
Mass. DWPC	Merrimack River [3103]	Feb. 1975 (part d)
	Shawsheen River [3104]	1975 "
	SuAsCo (Sudbury, Assabet, Concord Rivers) [3105]	June 1976 "

Mass. DWPC (cont.)	Nashua River [3106]	March 1975 " (Massachusetts basin plans will be updated by June 1979)
NH WSPCC	Merrimack River (4 sub-basins) [3110]	Feb. 1978

201 municipal wastewater treatment facilities plans. The 303(e) basin plans identify areas for which 201 facilities plans will be needed and priorities for construction. EPA and the states award construction grants to municipalities in accordance with state construction priorities and on the basis of adequate facility plans. The status of municipal facilities development is shown on Map 16 and in Table 9. The studies conducted by the COE (1974, [3113]) and Metcalf & Eddy (1976, [3107]) constitute a major input to 201 planning in studied areas. In the future, 208 areawide wastewater management plans will be coordinated with the 201 program for wastewater management in the basin. The 1977 Amendments to PL 92-500 make several significant changes in the 201 grant program. Additional funds and a more favorable cost sharing formula are provided for alternative and innovative treatment technologies. Provision has also been made for grants to privately owned wastewater treatment systems serving one or more residences or commercial establishments if public ownership is not feasible and if centralized treatment is less cost effective. Applicants will now be required to provide EPA with an analysis of the recreational and open space potential associated with the planned facility.

208 areawide wastewater management planning. 208 programs in the basin are being developed by RPAs for six designated areas and by both states (NHWSPCC and Massachusetts Department of Environmental Quality Engineering, (DEQE)) for undesignated areas. The 208 agencies, their grants, and estimated plan completion dates are listed in Table 10.

General concerns include the balancing and coordination of alternative solutions to wastewater management, the identification of non-point source pollution, and the development of an implementation plan for recommended solutions. When completed, these plans or plan elements will be certified by the states and incorporated into the 303(e) basin plans. EPA will be responsible for reviewing the Massachusetts and New Hampshire 208 plans to ensure that the plans are consistent.



Municipal Treatment
Merrimack River Basin

0 miles 5 10

BASE MAP SOURCE: USGS HYDROLOGIC UNIT MAP, 1:500,000, 1974; TOWN LINES, NERBC, 1:500,000, 1976.

16
MAP NO.

Table 9: Existing and Proposed Municipal Sewage Treatment Facilities

	Town	Other Towns Served	Receiving Water	Design Flow or (Approximate Waste Flows) (MGD)	Present Level of Treatment	Proposals
Pemigewasset subbasin	Lincoln		E. Branch Pemigewasset R.	.40	S	
	Woodstock		Pemigewasset R.	.15	S	
	Waterville		Mad R.	.55	A	
	Plymouth		Pemigewasset R.	.58	P	Secondary treatment
	Ashland		Squam R.	1.6	S	
	New Hampton		Pemigewasset R.	.08	S	
	Bristol		Pemigewasset R.	.23	S	
Lake Winnipesaukee subbasin	Moultonborough	Center Harbor	Lake Winnipesaukee	.20	S	To be abandoned; The Winnipesaukee River Basin Project will connect these sewers and other new lines (to Alton, Gilford, Belmont, Northfield, Tilton and Sanbornton) to a treatment facility at Franklin, discharging into the Merrimack River
	Meredith	Center Harbor	Lake Winnipesaukee	.26	S	
	Laconia		Winnisquam Lake	4.75	A	
	Wolfeboro		Land disposal	.14	A	
Contoocook subbasin	New London		Kezar Lake	.30	A	Regional interceptor to Lake Sunapee facility (out of basin)
	Henniker		Contoocook R.	(.30±)	S	
	Peterborough		Contoocook R.	.5	S	
	Jaffrey		Contoocook R.	.44	S	
	Warner		Warner R.	(.17±)	S	
	Hopkinton		Contoocook R.	(.25±)		
	Hillsborough		Contoocook R.	(.58±)		Proposed secondary treatment
	Antrim		Contoocook R.	(.27±)		
	Bennington		Land disposal	(.09±)		
	Pittsfield		Suncook R.	(.5 ±)	P	Secondary treatment (1979)[2]
	Allenstown	Pembroke	Merrimack R.	(1.3 ±)	S	
	Greenville		Souhegan R.	0.05	S	
	Milford	Wilton	Souhegan R.	(.20±)	S	Secondary treatment

[1] P-primary; S-secondary; and A-advanced

[2] combined sewer solutions planned

Merrimack main stem subbasin

Town	Other Town Served	Receiving water	Design Flow or (Approximate Waste Flows) (MGD)	Present Level of Treatment[1]	Proposals
Weare		Piscataquog R.			Secondary treatment
Goffstown		Piscataquog R.	.30	P	Secondary
Derry		Beaver Brook	.55	S	Upgraded treatment (1981) and relocation of discharge to Merrimack River
Salem		Spickett R.	1.3	S	Advanced treatment (1981)
Merrimac		Merrimack R.	2.0±)	S	Alternatives include secondary treatment with land disposal; advanced treatment to Cobbler Brook; secondary treatment to Merrimack River. Sewers to serve Haverhill
Amesbury		Merrimack R.	1.9	S	
Salisbury		Black Rock Creek (to Merrimack R. estuary)	(2.0±)	None	Secondary treatment or equivalent; alternatives include land disposal, or connection to Newburyport
Concord	Boscawen	Merrimack R.	1.9	S	2
Concord	Bow	Merrimack R.	(10.0±)		Secondary treatment
Hookset		Merrimack R.	.22	S	
Manchester		Merrimack R.	(20.0±)		Secondary treatment facility under construction (1977), with sewers to serve Bedford[2]
Merrimack		Merrimack R.	5.0	S	
Nashua		Merrimack R.	12.7	P	Secondary (1978), with sewers to serve Hudson[2]
Lowell	Dracut Tewksbury	Merrimack R. Concord R. Beaver Brook	32.0		Secondary treatment under construction 1977; 32 mgd[2]
Chelmsford					Alternatives include connection to Lowell; a regional facility with Tyngsboro and Westford connection to Billerica
Lawrence	Andover N. Andover Methuen	Merrimack R.	52.0	S	2
Haverhill	Groveland	Merrimack R.	18.0	S	2
Newburyport		Merrimack R. estuary	(3.0)	P	Secondary treatment and sand filtration; sewers to serve Newbury

[1] P-primary; S-secondary; and A-advanced

[2] combined sewer solutions planned

	Town	Other Town Served	Receiving Water	Design Flow or (Approximate Waste Flows) (MGD)	Present Level of Treatment [1]	Proposals
Nashua subbasin	Fitchburg West		N. Nashua R.	10.0	A	Sewers to Westminster
	Fitchburg East		N. Nashua R.	10.0	A	Sewers to Lunenburg
	Leominster		N. Nashua R.	(6.0)	S	Advanced treatment
	Clinton		Nashua R.	(2.0)	S	Advanced treatment, sewers to Lancaster
	Ayer		Nashua R.	(.72)	P	Secondary treatment, sewers to Groton, Shirley, and/or Townsend
	Pepperell		Nashua R.	1.0		Secondary treatment
	Holden, Boylston, Rutland		to Upper Blackstone Water Pollution Abatement District			
SuAsCo subbasin	Westborough		Assabet R.	1.1	S	Advanced; possibly with Shrewsbury
	Shrewsbury		Assabet R.	1.95	S	Advanced; possibly with Westborough
	Marlborough West	Northborough	Assabet R.	2.0	S	Advanced treatment; possible sewers to Berlin
	Marlborough East		Hop Brook (Sudbury)	5.5	A	Transfer discharge
	Hudson		Assabet R.	2.0	S	Advanced treatment
	Maynard		Assabet R.	1.3	S	Advanced
	Hopkinton, Framingham, Ashland, Bedford, Lexington, Natick		existing or future Metropolitan Sewer District			
	Concord		Concord R.	1.0	S	Advanced; possible sewers to Acton, Littleton, Maynard
	Billerica		Concord R.	1.6	S	

All SuAsCo facilities will require ammonia and phosphorus removal.

[1] P-primary; S-secondary; and A-advanced

[2] combined sewer solutions planned

Sources: MADWPC, 1975, 1976 [3103, 3104, 3105, 3106]; NHWSPCC, 1973 [3110]

TABLE 10: Designated 208 Planning Agencies

	208 Agency	Grant	Completion Date
1)	Lakes Region Planning Commission	$532,880	6/78
2)	Strafford-Rockingham Regional Council	$270,000	6/78
3)	Montachusett Regional Planning Commission	$377,000	5/78
4)	Northern Middlesex Area Commission	$479,700	6/78
5)	Metropolitan Area Planning Council	$2.29 million (total area)	7/78
6)	Central Massachusetts Regional Planning Commission	$1.35 million (total area)	7/78
7)	Massachusetts Department of Environmental Quality Engineering (DEQE) (includes Merrimack Valley Planning Commission area)	$320,000 (total state)	6/79
8)	New Hampshire WSPCC	$336,850 (total state)	6/79

The recent amendments to Section 208 and to the relationship of other PL 92-500 programs to the 208 program are worthy of a brief review. Perhaps most importantly, the continuing authorizations will enable the completion and implementation of areawide wastewater management planning. The 208 plans are directed to include an evaluation of the recreational and open space opportunities derived from improved water quality and from potential uses of treatment facility sites. Several amendments deal with the implementation of certified 208 plans. The administrator of EPA is directed to enter into agreements with other federal entities to ensure maximum use of existing laws and programs for 208 plan implementation. In addition, the Secretary of Agriculture is authorized to enter into long term contracts with landowners for the purpose of implementing, on a cost share basis, approved best management practices for the control of NPS pollution from farming and forestry activities. Finally, the relationship between the 404 permit program and any similar program adopted by a state as part of a 208 plan is clarified so as to avoid regulatory duplication.

Lakes-related programs. Both states conduct baseline surveys of lakes and ponds and assessments of eutrophic conditions through their

respective lakes programs. Massachusetts has also completed three intensive lakes studies in the basin. Federal funds for water quality restoration, while increased under the Section 314 amendments of PL 92-500, have not been extensively used by either state due to a 50/50 matching formula and the past emphasis on lakes restoration as opposed to comprehensive management or monitoring. The two 314 projects in the basin, Lake Cochituate and Lake Nutting, have received 25% funding from Massachusetts through its Research and Demonstration program.

State policies to restrict point discharges of nutrients into lakes are implemented through facilities planning and discharge permit programs. In the New Hampshire portion of the basin, sewer construction is planned around 5 eutrophic and 10 mesotrophic lakes. To the extent that NPS pollution affects lakes as well as streams, lake eutrophication is being indirectly studied through 208 programs. However, both the Lakes Region and Strafford-Rockingham RPAs have included specific lakes related concerns in their 208 planning. The former has conducted intensive monitoring of lakes and tributaries. Both emphasize the importance of controlling shoreline uses, particularly subsurface disposal systems, in preventing eutrophication problems.

Monitoring and enforcement programs. Both states conduct ongoing water quality monitoring and surveillance programs through an extensive network of state and federal monitoring stations. These programs provide the basis for identifying continuing water quality problems, setting abatement priorities and initiating enforcement actions. Streams have received the primary emphasis in the monitoring programs. As a result, groundwater and lake water quality monitoring are less comprehensive in scope and are often oriented to specific resource problems or research and demonstration projects.

Water quality standards are enforced through the NPDES permit program administered by EPA in cooperation with the states. Permits have been issued to all major dischargers in the basin and stipulate secondary treatment for municipal discharges and Best Practicable Technology for industries. The issuance of second round permits, currently underway, will stipulate higher levels of treatment to meet Class B standards, as for example on the Assabet River. Correction of combined sewer problems is also dealt with through the NPDES permit program on a case by case

basis. However, the states and EPA are aware of the intensive capital investment needed to mitigate this problem and are unlikely to require the separation of all combined systems.

Section 404 of the Act authorizes the Corps of Engineers to administer a permit program to regulate the discharge of fill or dredged material in navigable waters of the United States, tributaries, and adjacent wetlands. This program constitutes an important means of dealing with NPS pollution from shoreline and riverine development within the basin. Under the 1977 amendments, a state can administer the 404 program of individual and general permits for navigable waters, except those suitable for interstate or foreign commerce and their adjacent wetlands.

4.2.3 Findings and Recommendations

Despite a considerable investment in pollution abatement and concomitant improvements in water quality, water pollution continues to be a major problem in the Merrimack basin. Many of the remaining problems appear to be adequately addressed by existing programs. Efforts to complete construction of sewage treatment facilities, maintain their operational effectiveness and correct combined sewer overflows will continue to be focused in Nashua, Fitchburg, Leominster, Concord, Manchester, Lowell and Lawrence. Additional sources of water pollution will be addressed by the PL 92-500 Phase II planning and management efforts initiated in 1977. Major concerns include the maintenance of water quality, control of NPS pollution, and identification of alternative solutions to wastewater management. The primary mechanisms which will direct this new effort are the Section 208 and 303(e) management plans. It is clearly essential that these programs be effectively coordinated with the 201 construction grants program if the 1983 water quality goals are to be achieved.

Planning. A variety of alternative measures, including dam and sediment removal, instream aeration, and flow augmentation were proposed by the Nashua River Program to meet the water quality goals in the Nashua basin (Camp, Dresser & McKee, 1975 [3102]). *These and other nonconventional measures should be evaluated through the 208 and 303(e) programs conducted by the Montachusett Regional Planning Commission, and the Massachusetts Department of Environmental Quality Engineering (DEQE) and Division of Water Pollution Control.*

Water quality problems in the SuAsCo basin are related to the existence of point sources of pollution in the headwaters and slow flow conditions throughout the basin. High population growth and some anticipated industrial expansion may increase the load on the rivers' assimilative capacity. *The Metropolitan Area Planning Council and DEQE, through the 208 program, should determine what implications the 1983 water quality goals will have for future types, levels, and locations of development in this area.*

In the drainage of the main stem downstream from Haverhill, water quality problems are related to municipal discharges and NPS contributions to small streams in Derry, Salem, Amesbury, Salisbury and Merrimac. NPS pollution from extensive shoreland development in this area is also associated with the water quality problems. In New Hampshire, both situations could be aggravated by a continuation of the high growth rates.

Advanced waste treatment, land disposal, and waste transhipment to the Merrimack have been variously proposed by New Hampshire, Massachsetts, and the COE to correct point source problems. The Strafford-Rockingham Regional Council 208 program has considered intensive regulation of subsurface disposal systems for NPS problems. Final resolution should come from both 208 and 201 programs. New 208 authorizations should assist planning efforts in the Merrimack Valley Planning Commission area in Massachusetts. *The statewide New Hampshire 208 program should pay special attention to the towns in this area which are not covered by designated agency programs.*

Both states should consider taking advantage of the PL 92-500 amendments that encourage alternative, innovative, and privately owned treatment systems. These approaches appear to be potentially relevant to the southeastern portions of the basin.

Although 208 planning is not yet complete throughout the basin, the draft plans issued to date, such as for the Lakes Region Planning Council, indicate that land use controls offer cost effective means of controlling NPS contributions to water quality problems. *The 208 agencies and EPA should develop and encourage the implementation of best management practices for existing and future NPS pollution that respond to water quality goals and the varying assimilative capacity of the receiving water bodies.*

4.3 FLOODING

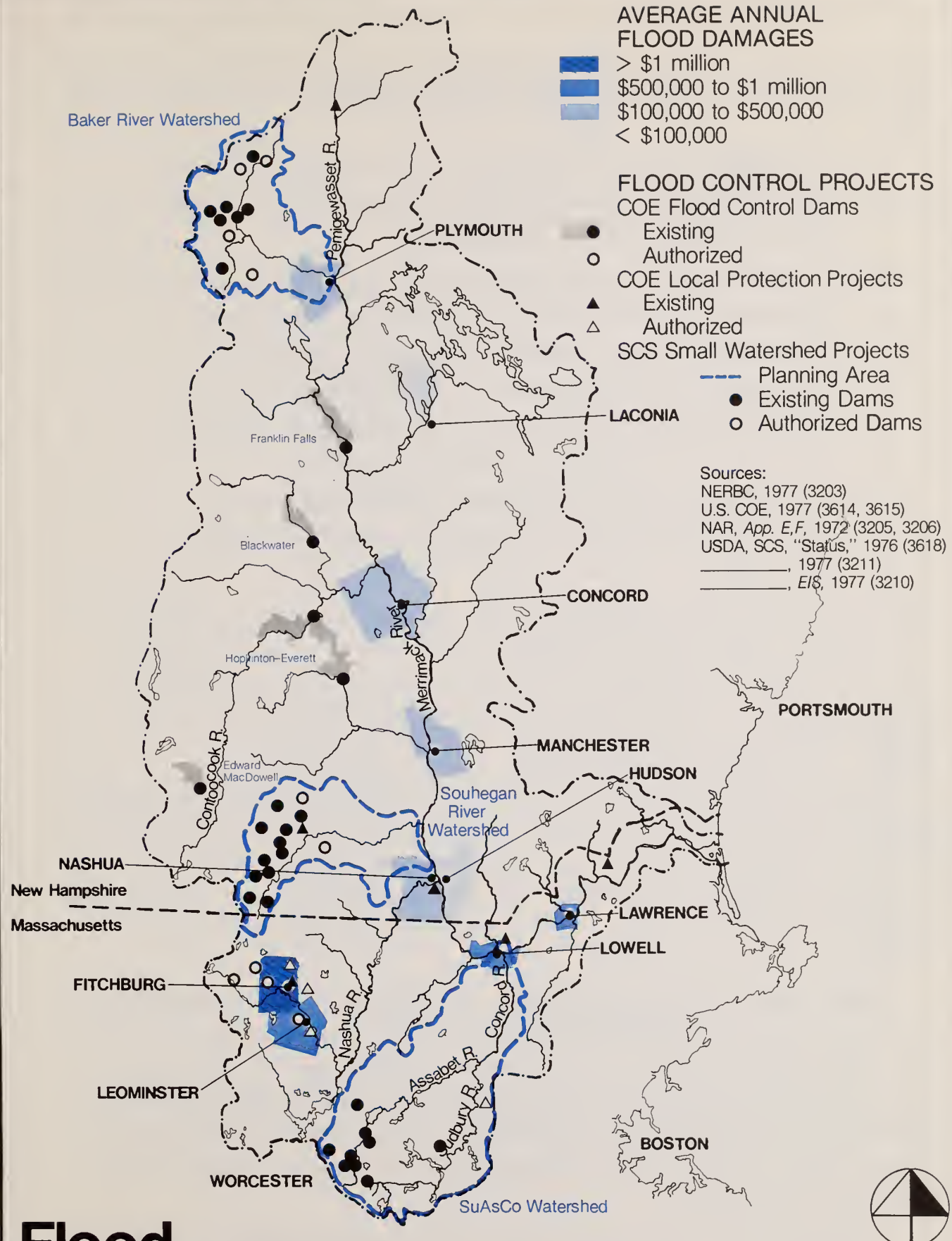
4.3.1 Existing Conditions: The Flooding Problem

The concentration of homes, industries, roads and utility corridors within flood plains is an established pattern of development around most urban areas in the southern half of the basin. This pattern aggravates the flooding process by preempting the natural storage function of flood plains and ultimately increases susceptibility to annual flood damages. The two major flood events, against which flood control projects and plans continue to be gauged, occurred in 1936 and 1938. Heavy spring rains coupled with snowmelt and saturated soils caused the flood of record in 1936. Damages of $35,000,000 resulted, with 80% of the loss on the main stem and over 70% of the loss to urban and industrial properties, primarily at Concord, Manchester, Nashua, Lowell, Lawrence, and Haverhill (NENYIAC, 1954 [3201]).

Beginning in 1936, the COE has investigated the need for flood control projects in the Merrimack basin. Four flood control reservoirs, controlling a third of the basin's drainage, and five local protection works have reduced average annual downstream damages by 55%. However, due primarily to inflating property values and continued flood plain development, downstream flood damages are projected to rise from $4 to $12.2 million by the year 2000. Of these damages, 59% occur on the Merrimack, and 22% on the Nashua, with Fitchburg having the highest average annual damages of over $1 million (see Map 17). While damages in upstream rural areas are less than the primarily urban property damage at downstream cities, they were $2.4 million in 1966, and are expected to reach $7 million by 2000. The largest damages occur to commercial and industrial properties and transportation facilities (NAR, App. E&F, 1972 [3506]).

4.3.2 Plans and Programs

A Unified National Program. In 1976, the U.S. Water Resources Council issued its report on A Unified National Program for Flood Plain Management.



Flood Damages & Projects
Merrimack River Basin

0 miles 5 10

BASE MAP SOURCE: USGS HYDROLOGIC UNIT MAP, 1:500,000, 1974; TOWN LINES, NERBC, 1:500,000, 1976.

17
MAP NO.

The report pinpoints the following needs with respect to flood plain management:

- to broaden objectives beyond flood loss reduction to include total flood plain management and protection of the natural and beneficial values of this resource;
- to fully consider alternative strategies in developing flood plain management plans, including the modification of flood flows, i.e., through flood control dams; the modification of susceptibility to flood damages, i.e., through flood plain zoning, and the modification of flood impacts, i.e., through flood insurance; and
- to unify and coordinate government efforts, including a lead role for the states in directing flood plain management efforts.

The implications of the Unified National Program for the New England region are currently being examined by NERBC's Task Force on Flood Plain Management. The reader is referred to the work of the Task Force for more in-depth information on what agency actions will be needed regionwide in order to implement the program (NERBC, 1977, [3203, 3204].

Massachusetts is currently directing its existing programs to conform with certain principles of the UNP. The Division of Water Resources has proposed measures to facilitate and implement nonstructural approaches to flood plain management. The Department of Environmental Quality Engineering is developing policies to deal with problems in their relevant regulatory programs.

Flood Control Plans and Projects. Through the 1960s, the modification of floods through structural solutions was a major program emphasis. The U.S. Army Corps of Engineers (COE) sponsored 4 flood control dams and 5 local protection projects at a cost of $69,600,000 (up to 1966). The U.S. Department of Agriculture Soil Conservation Service (SCS) sponsored upstream projects through three watershed protection projects under PL 566 (see Map 17 and Table 11).

Implementation of the early flood control projects under the Army Corps of Engineers authorization was delayed by local resistance in New

Table 11
Corps of Engineers
Authorized Flood Control Projects in the
Merrimack River Basin

NAME AND STATE	RIVER	DRAINAGE AREA (sq. mi.)	FLOOD CONTROL STORAGE (ac. ft.)	STATUS
DAMS AND LAKES				
Franklin Falls, NH	Pemigewasset	1,000	154,000	Complete
Edward MacDowell, NH	Contoocook (Nubanusit Brook)	44	12,800	Complete
Blackwater, NH	Contoocook (Blackwater)	128	46,000	Complete
Hopkinton-Everett, NH	Contoocook and Piscataquog	490	157,300	Complete
Whitmanville, MA*	North Nashua (Whitman)	17.5	6,700	Under design
Nookagee, MA*	North Nashua (Phillips Brook)	11	4,700	Under design
Monoosnoc, MA*	North Nashua (Monoosnoc Brook)	2.5	800	Under restudy
Phillips, MA	North Nashua (Phillips Brook)	5	1,600	Authorized
Mountain Brook, NH**	Contoocook (Mountain Brook)	13	5,300	Inactive
Bennington, NH**	Contoocook	186	90,000	Inactive
Beard's Brook, NH**	Contoocook (Beard's Brook)	120	35,000	Inactive
LOCAL PROTECTION WORKS				
Lincoln, NH (2)	E. Br. Pemigewasset			Complete
Nashua, NH	Merrimack and Nashua			Complete
Wilton, NH	Stony Brook			Complete
Lowell, MA	Merrimack			Complete
Haverhill, MA (1)	Merrimack and Little			Complete
Fitchburg, MA (1)(2)	North Nashua			Complete
Saxonville, MA	Sudbury			Under design
Fitchburg, MA (3)	North Nashua			Under design
Leominster, MA	North Nashua (Monoosnoc Brook)			Under restudy
North Andover and Lawrence, MA***	Merrimack and Shawsheen			Inactive
Fitchburg-Lunenburg, MA	North Nashua (Baker Brook)			Inactive

(1) Emergency Relief Appropriation projects (1937-39)
(2) Small flood control project accomplished under emergency authority
(3) Rehabilitation of existing project

* Multiple-purpose reservoirs
** Projects have been recommended for deauthorization under the provisions of Section 12, Public Law 93-251
*** Project has been recommended for deauthorization under the provisions of Section 12, Public Law 93-251

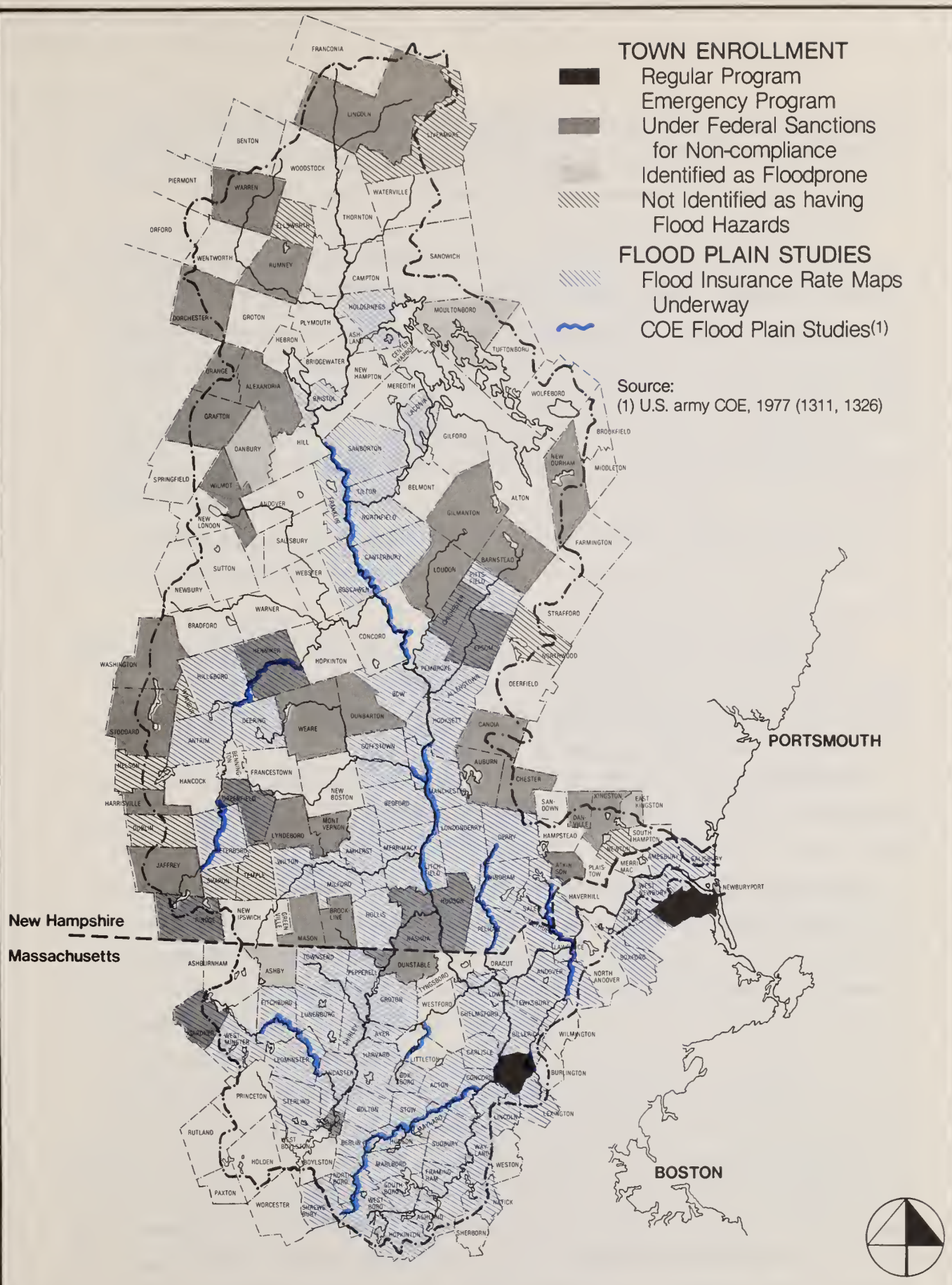
Source: COE, 1977 [3213, 3202]

Hampshire. The resistance centered on loss of local tax revenues in conjunction with the federal taking of land for impoundments that would primarily benefit downstream urban areas in Massachusetts. The issue was resolved through an interstate compact creating the Merrimack River Valley Flood Control Commission in 1957. Based on the compact, the state of Massachusetts is obligated to reimburse New Hampshire for 70% of the local tax revenues annually lost because of federal land ownership around flood control projects.

The most recent comprehensive flooding study was done by the COE in 1972. After evaluating 34 sites for structural flood control, the COE recommended no additional structural measures due to the lack of economic feasibility and political acceptability (COE, 1972 [3208]). The series of authorized (1966) but unconstructed reservoirs and local protection works in the Nashua River watershed are undergoing continued review by local interests. Six PL 566 dams in the Baker and Souhegan watersheds also remain unconstructed.

Section 73 of the Water Resources Development Act of 1974 directs federal flood management agencies to consider nonstructural solutions to flooding problems, and authorizes federal cost sharing for a minimum of 80% of project costs. Since this level of cost sharing is similar to that for structural projects, Section 73 increases the feasibility of a balanced management strategy. However, none of the recent studies investigated nonstructural flood plain management as an alternative to structural solutions. Thus, because Section 73 funds can only be obtained for implementing specific studies, they are not currently available for the basin. In addition, implementation of Section 73 has been delayed by OMB, in response to concerns over 1) the adequacy of planning procedures in determining the optimal mix of solutions and 2) the budgetary impact of this cost sharing policy.

Flood Insurance Program. The U.S. Department of Housing and Urban Development (HUD) Flood Insurance Program incorporates two strategies: insurance of private property against flood losses coupled with flood plain regulations for participating towns. As shown on Map 18, almost all basin communities are enrolled in the emergency program, but only 2 have entered the regular program. As of June 1977, thirty-eight towns were under



Flood Insurance Program
Merrimack River Basin

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BASE MAP SOURCE: USGS HYDROLOGIC UNIT MAP, 1:500,000, 1974; TOWN LINES, NERBC, 1:500,000, 1976.

18
MAP NO.

federal sanctions for noncompliance with program requirements. Flood insurance rate maps must be completed before a community can enter the regular program. The status of this mapping is shown on Map 18.

Flood Preparedness Planning. Both New Hampshire and Massachusetts have civil defense preparedness plans and will assist and guide communities in their disaster preparedness planning efforts as requested. However, few basin towns have taken advantage of this program and the number of towns utilizing flood warning systems and preparedness plans to reduce their susceptibility to flood damages is unknown.

Dam Safety. Under the National Dam Inspection Program (PL 92-367), the COE has inventoried all non-FERC dams more than 25 feet in height or impounding more than 50 acre-feet of water, and has rated them in terms of potential hazard. Over one-half of all dams in the basin received a high potential hazard rating. The COE is now proceeding with detailed dam inspections, based on state priority lists.

The Massachusetts Division of Land and Water Use has responsibilities, under Chapter 253, to conduct inventories and dam inspections. Current budget limitations and inconsistency between state and federal criteria have hampered the effectiveness of this program.

The New Hampshire Water Resources Board is responsible for the management of state owned dams in addition to the inspection of privately owned dams.

State Regulatory Programs. Flood plain development is regulated in Massachusetts under its Wetland Protection Acts. However, protection of the flood flow capacities of wetlands and flood plain resources is just one of several stated objectives in the Acts. Chapter 131, Section 40 requires an order of conditions for all physical alterations within 100 feet of the flood plain. Flood plain delineations generated by other agencies, COE, SCS and HUD, are used when available. Section 40A provides for the delineation and deed recording of all flood prone areas within which unauthorized obstructions or encroachments are prohibited. Within the basin, flood plains of the Nashua, Nissitissit, and Squannacook Rivers have been identified by the Massachusetts Department of Environmental Management and HUD contractors with sufficient accuracy to enable restrictions under this program. Implementation of Section 40A has been initiated along the Nashua.

Flood plain development in New Hampshire is indirectly regulated by the Special Board on Dredge and Fill (adjunct to the Water Resources Board).

4.3.3 Findings and Recommendations

Despite past and continuing investments in flood plain management in the basin, it is anticipated that flooding problems will increase. The Unified National Program represents an approach to dealing with flooding problems, both in terms of planning objectives and institutional frameworks, that would be of benifit if applied to the Merrimack River basin. However, effective flood plain management in the basin is hampered by the following factors:

- No basinwide flood plain management plan has been recently initiated.
- Although efforts are being made to coordinate flood plain management policy, especially in Massachusetts, the various regulatory programs directly and indirectly governing flood plain development are scattered across several state agencies.
- In the absence of a comprehensive plan and state leadership, no basis exists for integrating federal, state and local programs to achieve effective, basinwide flood plain management.
- Neither state nor federal government has provided funding to support a strong state role in flood plain management or in the development of a balanced strategy of structural and nonstructural solutions.
- The most direct funding for implementing nonstructural projects, Section 73, is not readily available. Because nonstructural solutions to flooding problems are anticipated to have a high effectiveness factor for the basin (NAR App. E, 1972 [3205]), the resolution of issues surrounding Section 73 cost sharing is critical to basinwide planning.
- Major responsibilities for flood plain management have been delegated to local governments. While the effectiveness of

local programs has not been monitored, the large number of basin towns under federal sanctions for noncompliance with Flood Insurance Program requirements suggests the need for stronger commitments and capabilities at the community level.

Federal, state, and local agencies are encouraged to deal with these problems through the following actions.

Planning. *It is recommended that Massachusetts and New Hampshire, in conjunction with the COE, SCS, and NERBC, develop a flood plain management strategy plan for the Merrimack River basin. Planning objectives should be developed to reflect the unique conditions and problems of the basin, so that the optimal mix of structural and nonstructural solutions can be achieved. Information needs include:*

- *flood plain characteristics, existing uses and use trends, the nature of flood events, and beneficial values and functions;*
- *flood damage figures, as are being developed by SCS in Massachusetts; and*
- *influences of upstream tributary flows on downstream flooding.*

The management plan should evaluate:

- *the effectiveness of alternative management strategies;*
- *the capabilities of existing programs to implement optimal strategies, particularly with respect to overall resource protection and maintenance of natural valley storage; and*
- *the need to develop state flood plain regulations in New Hampshire and to sharply accelerate implementation of the existing Section 40A Wetlands Protection Act in Massachusetts.*

Action. *Massachusetts and New Hampshire are encouraged to designate a lead agency or other coordinative mechanism to direct and coordinate federal, state, and local flood plain management programs. These state agencies, in conjunction with the COE, SCS, and NERBC, should initiate the development of the basinwide management plan. The potential role of the Merrimack Valley Flood Control Commission in orchestrating this effort should also be investi-*

gated. Federal funding for state program development and management should be made available.

In order to facilitate implementation of Section 73, the Water Resources Council should continue to develop planning procedures that can produce optimal solutions to flood plain management problems. Congress and OMB are encouraged to resolve the cost-sharing issues that are constraining implementation of the Section.

Massachusetts and New Hampshire should assist basin communities in carrying out their flood plain management programs through the provision of technical assistance. The states should consider focusing on the Flood Insurance Program and flood preparedness planning in their assistance efforts.

4.4 FISH AND WILDLIFE

4.4.1 Existing Conditions

The fisheries and wildlife of the Merrimack basin are an important natural and economic resource directly related to water quality and supply. Although these resources, especially fisheries, were greatly diminished by industrial activity in the 19th century, improving water quality and active management efforts are responsible for widespread recovery.

The ample supply of still and flowing waters in the Merrimack basin support substantial freshwater fisheries. Native brook trout reporduce in the coldwater lakes and streams to the north and west while warm water species and some seasonal coldwater fisheries dominate in the southern basin.

The Merrimack estuary supports a large recreational fishery and some limited commercial operations. The present commercial operations focus on clam worms and eels. The extensive softshell clam flats have been closed due to municipal pollution. Important recreational species include striped bass, flounder and mackerel.

Anadromous fish populations, once an important component of the Merrimack's fisheries, were severely affected by the pollutants and dam building associated with industrial activity. Efforts are underway to restore these populations.

The primary constraint on wildlife is ongoing habitat destruction. Although basinwide figures are difficult to obtain, regional trends indicate that wetland areas, a primary habitat, are diminishing at approximately 1% per year. The effectiveness of existing state programs in controlling this activity is difficult to assess.

4.4.2 Plans and Programs

Anadromous Fisheries. One of the most dramatic programs in the basin is that which seeks to restore the Atlantic salmon, shad and other anadromous fisheries. Recent improvements in water quality and federal interest in anadromous fisheries have created the impetus for a cooperative program involving the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the New Hampshire Fish and Game Department, and the Massachusetts Division of Fisheries and Wildlife and Division of Marine Fisheries. This project enjoys support from private sportfishing organizations throughout the basin and nationwide publicity. A variety of studies have been completed on breeding and spawning habitat, carrying capactities, flow requirements, water quality parameters and obstructions to migration. Salmon and shad stocking experiments and salmon brood stock development have been undertaken to demonstrate the feasibility of the project.

Although final estimates of the potential salmon and shad runs are being revised, the preliminary goals (for 1990) are the establishment of an annual run of 11,000 adult salmon and 1,000,000 shad with supplemental stocking (Technical Committee for Fisheries Management of the Merrimack River basin, 1977 [3503]). These goals are primarily dependent on two factors:

- construction of adequate fishways around obstructions (identified on Map 6); and
- sustained flow to insure adequate supply of dissolved oxygen, the function of fishways, and the migration inducing seasonal freshets.

The program participants are currently working with main stem dam owners to facilitate fish passage. The Public Service Company of New Hampshire and the owner of the Essex dam are responsible, under FERC licensing procedure, for providing passage at 8 dams, 2 currently licensed

and 6 in the licensing process. Special legislation has been submitted to Congress requesting funds to aid in construction of fishways for the unlicensed Lowell and Lawrence dams. Funds from the Lowell National Urban Cultural Park project may also be available. The program has also begun to accommodate concerns for both anadromous species of sturgeon, the Atlantic sturgeon (Acipenser exyrhynchus) and the shortnose sturgeon (Acipenser brevirostrum) which is an endangered species. Under the auspices of the Endangered Species Act (PL 93-205), the National Marine Fisheries Service is responsible for safeguarding all populations of the shortnose sturgeon. On the basis of historical records it appears that shortnose sturgeon contributed to an important commercial fishery on the Merrimack River; however, information regarding the current status of both species of sturgeon in the Merrimack is sparse. Under Section 7 of PL 93-205 the National Marine Fisheries Service is required to consult with other federal agencies, upon their request, to ensure that no activity authorized, funded, or carried out by a federal agency will jeopardize the continued existence of an endangered species or result in the destruction of designated critical habitat. To satisfy this responsibility, the National Marine Fisheries Service will continue to provide assistance to the project cooperators in evaluating the impacts of this project on the shortnose sturgeon.

Freshwater and Estuarine Fisheries. Management of freshwater fisheries is primarily concerned with satisfying recreational demand for coldwater species. The limited number of natural coldwater fisheries has necessitated stocking programs in both New Hampshire and Massachusetts. Stocked species include brown, brook, lake and rainbow trout. Less intensive management programs for bass and pike are also underway in New Hampshire and Massachusetts. Generally speaking, relatively low demand for warm water species and the abundance of suitable habitat obviate the need for more elaborate management. In Massachusetts, however, historical patterns of pollution have eliminated many of the warm water fisheries. It is anticipated that these fisheries will be reestablished as water quality improves. Monitoring programs for industrial pollutants and pesticides are also underway although no serious problems are indicated. Both states have completed adequate inventories of fish species, habitat, and managed fisheries.

With fishing opportunities evenly distributed throughout the basin, management agencies in both states feel that existing demand is adequately met. Latent urban demand, however, has been identified as a potential future pressure on the resource.

The Massachusetts Coastal Zone Program has designated the Merrimack estuary a Special Assistance Development Area. This designation targets the area for state investments to develop commercial fishing and recreational opportunities.

Wildlife. State wildlife management efforts are primarily concerned with the maintenance of game populations using such tools as monitoring, harvest regulation and habitat preservation. Additional objectives include protection of rare and endangered species as well as enhancement of a multitude of nongame species of wildlife which depend on wetlands and other water related habitat. The 7,254 acres of state owned wildlife management areas also provide habitat for many nongame species. The Wetlands for Wildlife Program administered by the Massachusetts Division of Fisheries and Wildlife has focused on acquisition in the Nashua and Nissitissit watersheds. The U.S. Fish and Wildlife Service maintains two wildlife refuges totaling 3,362 acres along the Sudbury, Concord and Nashua Rivers. In addition, various private groups maintain wildlife sanctuaries throughout the region. The Audubon Society alone holds 2,383 acres of wildlife refuges open to the public (see Map 19). Private groups and state agencies frequently cooperate on census projects and on species specific programs, especially concerning nongame species.

4.4.3 Findings and Recommendations

Planning. At the present time, the long-range implications of anadromous fish restoration for alternative uses of the river's resources are unclear. *The Atlantic salmon restoration strategy plan, currently being developed by the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the Massachusetts Division of Fisheries and Wildlife, Division of Marine Fisheries and the New Hampshire Fish and Game Department should provide an accurate picture of the benefits as well as the potential contraints on river uses of a successful restoration. The reevaluation should take into account the demand for and conflicts generated by other potential uses of the Merrimack including water supply, hydroelectric*

generation, cooling water for thermal generating stations, and recreation. NERBC should monitor continued planning for anadromous fish restoration to insure a balanced consideration of competing water uses.

Research. Coldwater sport fisheries are limited in the Massachusetts portion of the basin. This area constitutes a major center of existing and potential fishing demand. *It is recommended that the Massachusetts Division of Fisheries and Wildlife investigate latent urban demand for fishing opportunities.*

Action. The biological requirements of the basin's fisheries are strongly represented in existing water quality classifications and standards. Enforcement remains a continuing concern, however, particularly in regard to prevention of short-term extremes in temperature, turbidity, dissolved oxygen (DO) and other critical parameters. Localized water quality problems identified in other sections of this report, including sedimentation and depleted DO, have a substantial impact on fisheries depending on location and timing. This is especially true for coldwater fisheries and anadromous fish spawning areas. Fluctuations in streamflow and lake level are also fisheries related concerns. *It is recommended that the New Hampshire Water Supply and Pollution Control Commission (NHWSPCC) and the Massachusetts Department of Environmental Quality Engineering (DEQE), in cooperation with the states' fish and wildlife departments, strictly enforce water quality standards in areas of important cold water fisheries and spawning areas. The NHWSPCC, New Hampshire Department of Fish and Game and the New Hampshire Water Resources Board should cooperatively develop minimum flow agreements in areas of important coldwater fisheries and spawning areas.*

The limited and seasonal nature of the coldwater fisheries in Massachusetts and the heavy demand for coldwater sportfishing are a continuing management concern. *It is recommended that the Massachusetts Division of Fisheries and Wildlife and the New Hampshire Fish and Game Department should continue to encourage utilization of warm water species as a substitute to meet fishing demand.*

Ongoing destruction of habitat, especially in the southern half of the basin, poses a threat to the long-term stability and management of fish and wildlife populations. *It is recommended that the New Hampshire Water*

Resources Board , NHWSPCC, and the Massachusetts DEQE rigorously enforce wetland preservation statutes and encourage the use of current use assessment strategies in order that valuable fish and wildlife habitat is conserved.

4.5 EROSION

4.5.1 Existing Conditions

Water related impacts of erosion generally include increased nutrient load, turbidity, sedimentation, and runoff of toxic materials such as pesticides. Erosion can limit the utility of water for several important activities including habitat of fish and waterfowl, water supply, and recreation among others.

Four primary sources of sediment and eroded materials can be identified in the Merrimack River basin:

- construction activities, such as road building, subdivision development and sand/gravel operations;
- agricultural operations, especially those connected with tilled row crops;
- forestry operations, especially yarding and road building activities; and
- natural processes, particularly stream bank and channel erosion. This can be aggravated by structural alterations of stream channels.

In 1972, the NAR study, using data collected by the SCS and the U.S. Forest Service in 1966 [3301], indicated the Merrimack River basin was not considered an erosion problem area. In the years following the report, construction activity has increased significantly and agricultural practices have begun to favor more intensive farming methods. Both changes have resulted in increased rates of soil loss. A survey of the state and regional agencies involved in the 208 planning effort indicated that, although significant local erosion problems exist related to construction

activities, erosion was not the primary NPS impact on water quality. In addition, brief aerial inspections of basin erosion conditions conducted by the Corps of Engineers in late 1976 determined that local erosion problems occur along the Pemiqewasset and lower reaches of the East Branch Pemiqewasset River. Nonetheless, legitimate concerns exist from the point of view of soil conservation.

4.5.2 Plans and Programs

Erosion problems in the basin are treated under the auspices of a variety of federal, state and regional programs. Primary strategies focus on preventive land treatment measures and prescriptive land use regulations. The following is a brief summary of the major programs and planning efforts.

Treatment of local erosion problems has occurred primarily under the auspices of the Soil Conservation Service in cooperation with Soil and Water Conservation Districts (SWCD). Soil conservation measures, such as contour cropping, reforestation and buffer strips, are covered in these programs along with recreation, flood prevention, and fish habitat projects. PL 46 provides the authorization for most soil erosion projects by establishing an ongoing program of cooperation between SCS, Soil and Water Conservation Districts (SWCD) and local cooperators. Special projects, the scope of which transcends individual land parcels, are often dealt with as PL-566 watershed projects or as Resource Conservation and Development projects (PL-703). Projects are underway or have been completed on the Baker, Souhegan, SuAsCo, and Baboosic watersheds (approximately 529,690 acres or 16% of the entire basin).

Since erosion is a form of nonpoint source pollution, all designated 208 agencies are incorporating erosion control strategies in their areawide wastewater management programs. In view of the local nature of the erosion problem, the major management device will take the form of approved best management practices implemented through town zoning and subdivision ordinances. While enabling legislation exists in both New Hampshire and Massachusetts for erosion control via local zoning and subdivision regulations, few towns have effectively implemented any

control measures. Amendments to PL 92-500, recently enacted by Congress, are designed to facilitate the implementation of approved 208 plans by providing cost sharing incentives for local voluntary cooperation with existing SCS and SWCD programs.

Large-scale construction activities associated with state highway projects are a major source of erosion. Special concern is focused on such projects in proximity to important water bodies. The I-190 project in the vicinity of the Wachusetts Reservoir is an example of this situation. The U.S. Department of Transportation has prescribed standard specifications, incorporated into the state's contracts, which spell out the limits of allowable erosion and the appropriate control measures (i.e., culverting, runoff diversion, settling ponds).

The Section 404 programs administered by the Corps of Engineers regulates activities affecting virtually any surface water except perched wetlands. The permits required for small scale activity are presently handled by a general permit system which establishes guidelines and standards for activity types. Consideration of each individual application is limited to a determination of activity category. Implementation of the general permit system has recently commenced following resolution of federal legislation which clarified the scope of the 404 program.

Both New Hampshire and Massachusetts administer wetlands protection statutes which can be used to mitigate erosion related impacts of development in wetland areas. EIS and A-95 review procedures provide the states and RPAs with a method for suggesting modifications necessary to minimize erosion related impacts of federally funded projects. The states also provide limited technical assistance, in conjunction with RPAs, agricultural experiment stations and the Cooperative Extension Service, to towns and individuals in order to minimize construction related erosion.

4.5.3 Findings and Recommendations

Although erosion does not constitute an important basinwide problem now, the potential exists for significant problems if the growth anticipated in construction, forestry and agricultural activity occurs. This

is of special concern along the southern main stem and throughout the southern half of the basin where development pressure is strongest.

If and when these activities intensify and pose significant erosion problems, some action may be necessary to coordinate and extend the existing programs mentioned above. This effort will necessitate continued planning and active implementation.

Planning. Present 208 efforts, PL 46 and PL 566 provide a sound general approach to continued erosion planning. *It is recommended that EPA and Congress continue support of 208 planning as a means of coordinating the implementation of existing federal, state, regional and local erosion control measures.*

EPA and the states should fund the Merrimack Valley Planning Commission 208 project and similar programs in southern New Hampshire in order that a consistent planning effort is made in the heavily developed portions of the basin.

The PL 566 and PL 46 programs should be supported and maintained as multifunctional conservation tools. They could become important coordinative mechanisms if agricultural and forestry activity increases.

Action. *State regulation of erosion and sedimentation from large scale construction activity should rely on site adaptable techniques and frequent monitoring. Towns, with technical assistance from the RPAs, SWCDs, federal and state agencies, are encouraged to adopt specific design standards as a part of zoning and subdivision regulations in order to control construction related erosion.*

Implementation of 208 management plans should include elements designed to coordinate and support ongoing erosion control programs of federal, state and regional entities.

4.6 NAVIGATION

4.6.1 Existing Conditions

Historically, the estuarine cove at the mouth of the Merrimack served as a natural harbor for a thriving West Indies trade and commercial fishing fleet. Until the early 1800s, the town of Newburyport was one of the

largest ports of entry in Massachusetts, after Boston and Salem. Unique to most Massachusetts coastal harbors, Newburyport functioned as the terminus of water borne transport from upstream valley industries. Major shipbuilding industries also flourished along the lower Merrimack and continued to produce clipper ships and schooners until the 1880s. Schemes of the late '80s and '90s to maintain commerce on the river by dredging were undermined by the development of both the railroad and the Middlesex Canal. Newburyport was also the birthplace of the U.S. Coast Guard; in 1790, the first revenue cutter sailed from the harbor.

While the rich maritime history of Newburyport is still in evidence in the general atmosphere of the town, the harbor is now primarily used for recreational and only limited commercial navigation. The estuary offers over 500 moorings and slips, and several private yacht clubs and launching ramps. Commercial ocean fishing may be staging a comeback with the investment of state and federal money in a new harbor bulkhead and fish processing facilities (ice machine).

4.6.2 Plans and Programs

The Merrimack estuary has been designated in the Massachusetts Coastal Zone Management (CZM) plan as a Special Assistance Development Area. The potential expansion of fishing and recreation industries makes it a key area for state investment. The state supports the waterfront redevelopment, harbor channel maintenance, water quality improvements to reactivate clam harvests, and any feasible expansion of the depuration plant (Mass. CZM Program, 1977 [3401]). Planning assistance for these proposals is available from the state CZM office. The Massachusetts Department of Community Affairs has also completed a study on the revitalization of Newburyport harbor for commercial fishing and recreational boating.

Since the late 1880s, the COE has constructed two jetties at the inlet and has dredged parts of the Merrimack up to Haverhill (U.S. Army COE, 1977 [3403]). While Newburyport has requested the reactivation of the harbor dredging project, only dredging of the dangerous shoals at the mouth occurs on a continuous, biennial basis, at the request of the town and with the support of the state CZM program.

The only other navigation project implemented in the basin was the dredging of a channel between Lake Winnipesaukee and Paugus Bay in Laconia, N.H.. Completed in 1882, the 5' deep channel facilitates the passage of a mail boat as well as pleasure craft. Local interest in maintenance dredging has not been recently expressed (U.S. Army COE, 1977 [3404].

4.6.3 Findings and Recommendations

Commercial navigation on the Merrimack has declined to the point that it no longer constitutes a major concern. *However, the increase in commercial fishing and recreational boating on the lower river and estuary should continue to receive the program and project support of Massachusetts Coastal Zone Management and the COE.*

4.7 OTHER WATER DEMANDS

4.7.1 Forestry

Existing Conditions. The forests of the Merrimack River basin are one of the region's dominant physical characteristics as well as an important economic and social resource. The basin lies in the diverse transitional zone between the northern boreal forest and the central hardwoods. The major associations in this forest are the white/red pine, the sugar maple/beech/birch, and the elm/ash/red maple types. The basin is approximately 80% forested with a vast majority of that classified as commercial forestland.

Although inventories in New Hampshire and Massachusetts demonstrate that, as a whole, the region's forest volume is increasing, the growth in quality is not proportional. Approximately one in every three trees is classed as unmerchantable. The quality of saw timber has declined as the average diameter of pine and hardwood growing stock decreased.

The ownership patterns of forest land in the Merrimack basin reflect the situation in the entire New England region. Approximately 7% of the commercial forest land is held publicly and the remaining 93% is in private ownership. Most of the private landowners hold land in small parcels

(<10 acres) and the objectives of the owner are generally something other than timber production. The variety of objectives and the vast number of small holdings are obstacles to the expansion of the basin's forest industry.

Industrial utilization of the Merrimack basin's forest has changed dramatically over the years. While the basin supported an early lumber industry, the period between 1800 and 1850 saw the development of paper mills along the Nashua and southern main stem. However, since the development of very large ownerships and processing facilities in the Southeast and Pacific Northwest, the forest industry in the basin has declined. The present activities center on local and regional markets for lumber and, in the northern New Hampshire counties, pulp production. Between 1974 and 1976 the number of wood processing establishments declined 34% from 363 to 238. Comparable figures for employment and payroll are not available. The Division of Forests and Land (NH) and the Divison of Forests and Parks (MA) both foresee the potential for large industrial expansion given adequate markets. The development of fuelwood markets for low-grade timber has been suggested as a potential use of basin forest resources. An expanded particle board industry would provide another alternative market for presently unmerchantable timber. The principal obstacle to such utilization for large-scale particle board production is competition for the same resource from pulp and paper operations.

Plans and programs. The state laws and programs which apply to the forests of the basin can be considered in two groups. The aim of the first group is to regulate harvesting practices so as to protect water quality and aesthetic character. Forestry agencies in both states employ educational programs to improve forest practices. The second group of programs encourages long-range planning and open space preservation by relieving some of the short-term tax pressures on forest land owners. Current use assessment programs have enrolled 9,226 acres of forest land in the Massachusetts portion of the basin and approximately 200,000 acres in the New Hampshire portion. A yield tax is also levied on timber at the time of harvest.

Massachusetts has initiated a study of forest management and existing regulatory procedures in the state. Proposals for legislative revision of forest practices statutes have been developed.

The U.S. Forest Service is currently conducting a national planning effort under the Renewable Resources Planning Act of 1974 to determine its role in the management of the nation's forest resources. By 1980, the Forest Service intends to have completed an assessment of long term demands and supplies of forest resources and a program to coordinate management of the National Forests, State and Private Forestry Programs and Forest Service research. The approach to the New England region is currently being developed.

Findings and recommendations. The forest industry is a minor component of the basin's economic structure. Due to the low level of activity, there are few water related problems. The quality of the resource is declining, however, in the absence of active management.

The forces affecting forest management in the basin operate primarily at national, regional and state levels. Rising national demand for conventional forest products and recent interest in large-scale energy utilization of wood may at some future date rekindle interest in New England's forests. This interest faces several obstacles however, including fragmented ownership, nontimber ownership objectives, limited regional markets for New England's forest products and the declining quality of the resource base. The following recommendations made in the context of the Merrimack overview are appropriate throughout the region.

Planning. *The U.S. Forest Service, under the Renewable Resources Act of 1974, should develop management policies in cooperation with the states, for federal, state, and private forestlands with special consideration given to the unique role New England's National Forests play in providing recreational and nonmarket benefits, as well as timber, to the region.*

The states should develop comprehensive policies for forest resources management which coordinate existing harvesting regulations, current use tax programs and educational programs.

The Massachusetts Department of Environmental Management (DEM) and the New Hampshire Department of Resources and Economic Development (DRED) should conduct an analysis of the potential for expanded forestry activities with special attention to new local or regional markets and to mechanisms to efficiently manage small ownerships.

The DEM and DRED should review forest practices programs and evaluate their effectiveness in dealing with expanded forestry activities.

4.7.2 Agriculture

Existing Conditions. Farming has been part of the Merrimack's way of life since its earliest settlement. The opening of more fertile lands in the midwest and the lure of steady factory jobs sent New England's agricultural industry into decline in the mid-1880s. This trend has continued through the present, and has been aggravated by rapid suburban development in the southern half of the basin. Between 1964 and 1974 the number of farms and acreage in production declined 43% and 26%, respectively, while total farm acreage has declined 31%. The value of the average farm, on the other hand, has risen approximately 105%, creating enormous taxation pressures. Although the value of farm produce has risen dramatically, the costs of farming in the Merrimack have also increased, due to the lack of adequate farm service, food processing facilities and the necessity of importing basic materials such as feed grains. Bureau of Census statistics indicate that of the 1964-1974 decline, between 80% and 90% of the losses occurred in the first half of that period and that the rate of decline has lessened (see Table 12). It should also be noted that in the 1967-1974 period the value of farm production grew faster than the value of the farm itself.

Table 12: Changes in Agricultural Activity, 1964 - 1974

				annual rate of growth or decline (%)		
	1964	1969	1974	64-69	69-74	64-74
# of farms[1]	5991	3864	3433	-9.25	-2.5	-5.75
# acres in production[1]	190736	146108	141312	-5.5	-0.75	-3.0
# acres of farmland[1]	861380	601680	521712	-7.5	-3.0	-5.25
average value per farm ($)[2]	39669	62973	81963	9.5	5.5	7.5
production of average farm ($)[2]	14792	21765	34506	8.0	9.5	8.75

Source: U.S. Dept. of Commerce Census, 1964, 1969, 1974 [4003]

[1] derived from basin approximation including MA - Essex, Middlesex, Worcester Counties; NH - Belknap, Grafton, Hillsboro, Merrimack, Rockingham Counties.

[2] derived from NH and MA statewide figures adjusted to 1967 constant dollars.

Apple orchards and dairy products constitute the majority of the agricultural activity in the basin. Some truck farming for local markets also occurs. One of the heaviest burdens for dairy operation has been the need to import corn from the midwest. The figures indicating a rise in acreage in production may reflect an effort on the part of dairy farms to raise more feed grains locally.

The water related impacts of agricultural activity are related to runoff problems. Depending on the type of operation, runoff may contain sediment, high levels of fertilizers and other nutrients, or agricultural pesticides. These agricultural operations are generally classified as nonpoint sources and are being inventoried under the 208 program. None of the basin's designated 208 agencies indicated that this posed a severe problem although localized problems on smaller streams do exist.

Plans and Programs. Federal and state agencies have identified agricultural preservation as a component of both national and state resource management efforts. The Soil Conservation Service is conducting a nationwide inventory of prime and unique agricultural lands and currently has definitions and criteria under public review. Agricultural lands of national, state, and local significance are being identified and mapped. This process will be completed in the Merrimack basin over the next several years.

The Farmers Home Administration operates a loan assistance program aimed specifically at small farm operations. Both New Hampshire and Massachusetts have differential tax assessment programs which allow farmland to be taxed at a current use rate as opposed to its development potential. The success of these programs is limited due to a lack of a comprehensive approach to agricultural preservation. Massachusetts has initiated a program to preserve agricultural land. Under the recently adopted Agricultural Preservation Restriction Act, the state is able to purchase development rights from willing farmland owners. A pilot project has been started with a $5 million bond issue. New Hampshire has recently completed a statewide land use inventory which will be used in the development of an agricultural policy for the state.

Findings and Recommendations. Although both New Hampshire and Massachusetts are, to varying degrees, supporting agricultural preservation efforts, the long term decline trends appear to be continuing. The mech-

anisms needed to reverse this trend are, at best, poorly understood. The conversion of productive farm land to other uses threatens to foreclose options for future expansion of agricultural activity as well as the competitive position of the Merrimack's farmers in local and regional markets.

Data collection. *The SCS, in cooperation with the states, should expedite the identification of significant agricultural lands which are subject to immediate development pressures.*

Planning. *New Hampshire should consider the formulation of a state agricultural policy which establishes a management and planning framework within which long-term state agricultural goals can be attained. This policy should coordinate the current use tax program, educational/assistance programs and land use inventory efforts.*

Research. *The New Hampshire Department of Agriculture (DOA) and the Massachusetts Executive Office of Environmental Affairs (EOEA), in cooperation with USDA, should study the efficacy of a variety of preservation tools and strategies (purchase of development rights, preferential tax assessment, state operated support facilities, etc.).*

In developing agricultural preservation programs, NHDOA, MAEOEA, and SCS should evaluate the potential water related impacts of an enlarged and intensified agricultural industry.

Action. *NERCOM should assist the states in the development of regional marketing strategies and regional support facilities.*

4.7.3 Energy

Existing Conditions. Energy used in the Merrimack basin is drawn principally from a larger regional system. Although energy is converted, transported, and used within the basin, the factors governing most of these activities are not related to unique basin characteristics. However, this discussion is focused on the water related aspects of energy conversion and use which are directly relevant to the Merrimack basin with the primary emphasis on hydroelectric generation. Regional characteristics and programs are briefly described by way of background.

Energy use figures are presented, by source, for Massachusetts and New Hampshire as a general indication of probable use levels within the basin. Table 13 indicates the level of energy consumption in 1974 and

Table 13: Energy Use by Source, 1974 and 1990*

Sources by Area	1974 (%)	1990 (%)
New England	3117×10^{12} Btu's**	4110×10^{12} Btu's
Hydro	1.4	1.1
Nuclear	5.7	31.9
Gas	8.3	6.1
Coal	1.2	2.5
Oil	83.4	58.5
Massachusetts	1527×10^{12} Btu's	1934×10^{12} Btu's
Hydro	0.4	0.3
Nuclear	2.8	28.2
Gas	9.8	8.4
Coal	-	0.2
Oil	87.0	62.9
New Hampshire	199×10^{12} Btu's	325×10^{12} Btu's
Hydro	4.8	3.0
Nuclear	-	36.3
Gas	5.1	2.6
Coal	17.3	25.7
Oil	72.8	32.6

* 1990 projections derived under NERCOM "Case II" assumptions regarding fuel scarcity and conservation efforts.

** 1.8 million barrels of crude oil = 10^{12} Btu's. Source: NERCOM, 1975 [3606]

Table 14: Thermal Electrical Generating Capacity and Principal Stations in the Merrimack Basin (megawatts)

Principal Stations	Generating Capacity principal stations	total
Fossil Fuel/Steam		620
Merrimack (Bow, NH)	429	
Manchester (Manchester, NH	20	
Kelley (Manchester, NH)	19	
Internal Combustion/Gas Turbine		62
Merrimack (Merrimack, NH)	37	
Cherry St. (Hudson, MA)	20	

Source: NAR Appendix P, 1972 [3611]; NHWSPCC 303(e), 1973 [3110]; COE, 1977 [3009]

Table 15: Hydroelectric Installations

Plant or Site	Owner	River	State	Developed Installed Capacity (KW)	Developed Average Annual Generation (1,000 KWH)
Lawrence	Aquamac Corp.	Merrimack Canal	MA	900	4,500
Lawrence	Rowland Industries Inc.	Merrimack Canal	MA	1,920	6,000
Merrimac	Merrimac Paper Co., Inc.	Merrimack Canal	MA	600	2,300
Lawrence	Oxford Paper Co.	Merrimack Canal	MA	1,200	6,100
Lowell	Boott Mills	Merrimack Canal	MA	4,975	8,900
Lowell	Boott Mills	Merrimack Canal	MA	2,400	6,900
Lowell	Boott Mills	Merrimack Canal	MA	1,300	5,400
Pepperell	Pepperell Paper Co.	Nashua	MA	1,280	2,500
Fitchburg	James River Manf.	North Nashua	MA	250	
Wachusett	Metropolitan District Comm.	S. Br. Nashua	MA	3,200	
Wachusett Intake	Metropolitan District Comm.	Wachusett	MA	3,200	10,000
Oakdale	Metropolitan District Comm.	Quabbin Aqueduct	MA	3,500	10,645
Wilton	Hillsborough Mills	Souhegan	NH	600	1,000
Amoskeag	Public Service Co.	Merrimack	NH	16,000	82,700
Hooksett	Public Service Co.	Merrimack	NH	1,600	11,000
Garvins Falls	Public Service Co.	Merrimack	NH	7,200	40,000
West Hopkinton	Hoague Sprague Co.	Contoocook	NH	500	1,325
Jackman	Public Service Co.	N. Br. Contoocook	NH	3,200	8,000
Mill Wheel	Monadnack Mills Inc.	Contoocook	NH	750	1,900
Pierce Station	Monadnack Mills Inc.	Contoocook	NH	720	1,200
Monadnack Station	Monadnack Mills Inc.	Contoocook	NH	125	
Eastman Falls	Public Service Co.	Pemigewasset	NH	3,000	17,200
Ayers Island	Public Service Co.	Pemigewasset	NH	8,400	38,000
Lincoln	Franconia Paper Corp.	Pemigewasset	NH	1,025	4,500
				67,845	270,070

Source: Hydroelectric Power Resources of the U.S. FPC, 1976 [3620]

the projected 1990 level in the two states. The figures were generated by the Energy Program of the New England Regional Commission (NERCOM), and are based on an analysis of projected population growth in the region. The annual growth rates projected for Massachusetts and New Hampshire are approximately 1.5% and 3%, respectively. Growth in electrical demand, on the other hand, is expected to grow much faster (5%-MA, 8.5%-NH).

The water related impacts of energy use in the basin can stem from all aspects of energy use. This can be through transmission, either by pipeline or powerline, and electrical generation. However, the major impacts relate almost solely to generation. The water related impacts of energy transmission, usually minor in nature, result primarily from erosion related to the construction of transmission corridors. An extensive system of electrical transmission lines is already in place. Gas and oil pipelines are also a concern in the basin. There is presently a proposal by Tenneco in the permit and licensing phase, to construct a gas pipeline through the central portion of the basin. After initial review of this proposal, New Hampshire state agencies favor construction along the Public Service Company's existing right of ways.

The water related impacts of electrical generation are quite complex, including withdrawals and consumptive uses. This often involves direct competition with other water using activities for water resources. The primary facilities and the total installed capacity are indicated in Tables 14 and 15. The Federal Energy Regulatory Commission (FERC), in its publication, Hydroelectric Power Resources of the United States 1976 [3620], has indicated that some 415 MW of undeveloped hydroelectric potential existed in the Merrimack basin. It should be understood that this constitutes an inventory of office studies and does not reflect detailed site studies or economic feasibility. In 1976, an adhoc working group of the New England Federal Regional Council revised this figure to 135 MW which could be developed at the four sites listed in Table 16. A proposal to renovate the generating facilities at the Essex Dam is currently before the FERC licensing board. In addition, an undetermined amount of hydroelectric potential exists in the form of undeveloped and abandoned small dam sites throughout the basin. A recent

inventory conducted by the Corps of Engineers located some 350 impoundments in the basin, although it is unknown how many of these would be suitable for hydroelectric generation. There are presently no plans for major expansion of thermal generating capacity.

Table 16: Potential Hydroelectric Sites in the Merrimack Basin

Site Name and Location	Design Capacity in megawatts
Livermore Falls Campton, NH	35
Tilton Franklin, NH	20
Riverhill Penacook, NH	30
Moores Falls Merrimack, NH	50
Total	135

Source: New England Federal Regional Council, 1976 [3622]

The effects of these existing and proposed facilities are related to water quality and flow. Thermal generating stations with once-through cooling facilities discharge large amounts of cooling water that raise the river's temperature and reduce dissolved oxygen levels. This affects fish habitat and the ability of the river to assimilate other waste. The major energy related thermal discharge occurs at Bow, New Hampshire. This coal fired station owned by the Public Service Company, is licensed by EPA to discharge cooling water at the approximate rate of 690 mgd. This discharge, under the conditions of the permit, cannot raise the river's temperature more than $5^{\circ}F$ generally or $1^{\circ}F$ if the ambient water temperature is above $68^{\circ}F$. This permit will be subject to reissue in late 1979 at which time a final decision will be made as to the severity of the environmental impacts. Modern day thermal plants use cooling facilities that do not raise river temperature. Hydroelectric

facilities may alter flow characteristics affecting fish habitat, assimilative capacity, and the availability of water for water supply systems. Provision for minimum instantaneous flow would mitigate many of these adverse effects. The extent of these efforts will depend on the mode of operation (peaking, base, etc.) and the type of technology designed for each particular installation. The current emphasis, outlined below, is on the development of low head potential generally using natural river flows.

Plans and Programs. A large number of federal, regional, and state agencies are conducting energy planning programs in New England which have some impact on the Merrimack River basin. Most of this effort is directed at effectively managing the energy systems of New England as a whole. Several programs are underway which directly involve the basin's water resources.

NERBC is currently conducting a study to evaluate the potential of and devise a strategy for hydroelectric development regionwide. This study, scheduled for completion in 1981, will involve cooperative efforts by the New England states, New York and several federal agencies (COE, DOI, FERC, DOE, and SCS). Study elements will include an assessment of hydroelectric market potential, an inventory of existing hydroelectric facilities suitable for rehabilitation or expansion, and a reconnaissance of new sites with hydroelectric potential. The sites identified in Table 16 will be included in this study.

The Corps of Engineers is conducting a nationwide inventory of existing dams and the undeveloped hydroelectric potential represented at those sites. This effort is being coordinated with the NERBC study.

The Department of Energy has recently solicited proposals for feasibility studies of low head hydroelectric potential. The program is designed to demonstrate the power potential represented by these small sites. The studies will be conducted on a case-by-case basis and will only cover expansion or rehabilitation of sites with less than 20 meters of hydraulic head and between 50 kw and 15 mw of generating capacity. To date, two grants have been awarded in the basin at Goffstown and Concord, NH.

Findings and Recommendations. The present complex system of energy planning demands a coordinated effort to determine the energy needs and resources of the region. Future energy production may compete with other

activities for the use of the basin's water resources. New energy production in the Merrimack basin will, in the near future, focus primarily on the development of hydroelectric sites. The current emphasis on low head hydro potential may have the result of diffusing the related impacts throughout the basin rather than concentrating them on several main stem sites. Federal programs to improve water quality and to restore anadromous fisheries require the maintenance of flow levels which may hinder hydroelectric development. All uses of the river's water must recognize and resolve the conflicts inherent in satisfying varying demands.

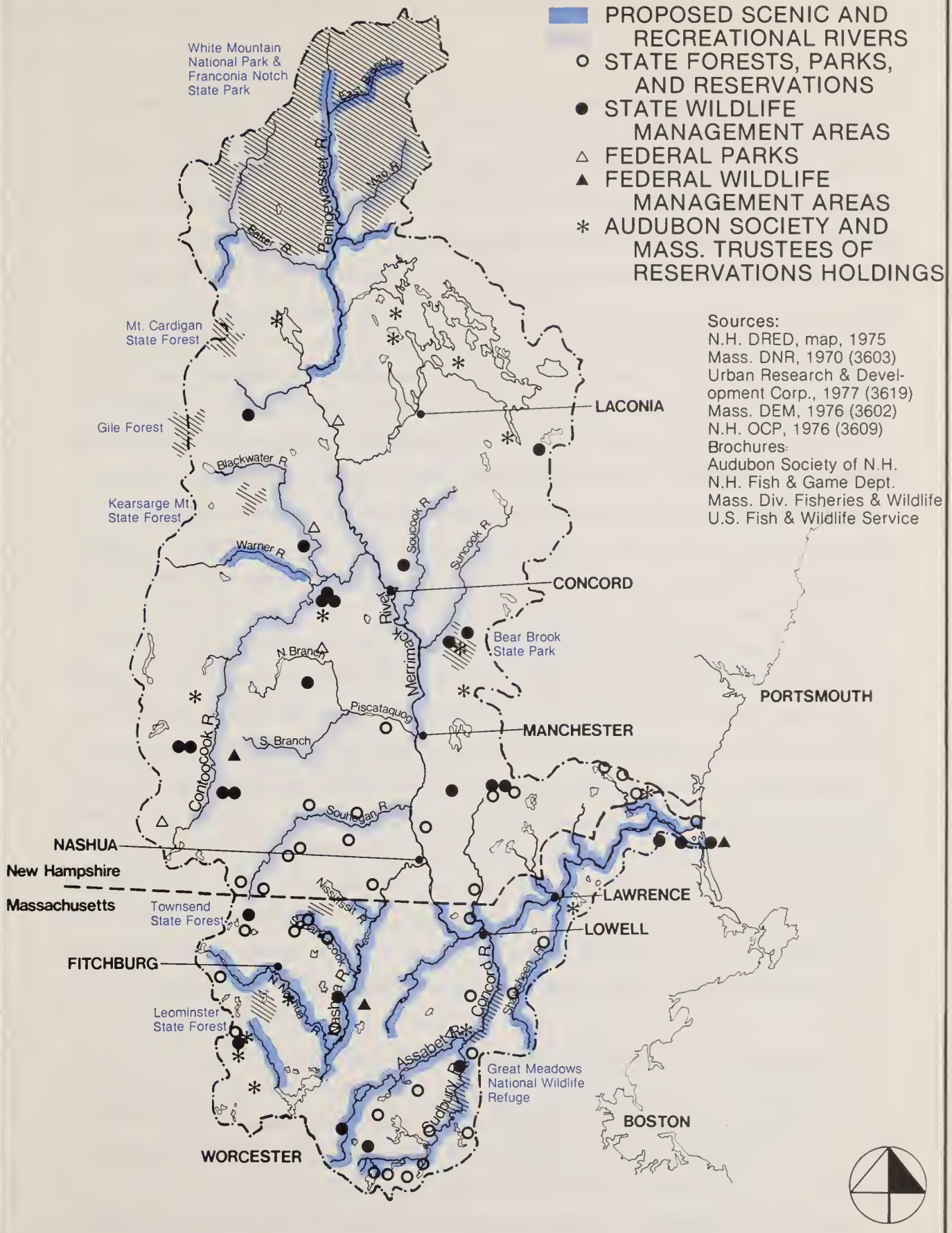
Planning. *The states should consider developing a regional energy planning framework in close cooperation with the private sector and appropriate federal and regional agencies. This effort should identify the criteria for locating new energy facilities and should evaluate the potential role of hydroelectric generation.*

Current hydropower evaluation efforts conducted by NERBC, COE and DOE should include analysis and review of cumulative impacts on the river basin's resources, so that fully informed decisions can be made on the relative merits of hydro proposals.

4.7.4 Recreation

Existing Conditions. Recreation represents a major, nonconsumptive use of the water resources of the basin. Existing state, federal, and other institutions' parks and reservations are shown on Map 19. The states own approximately 70,900 acres of parks and forest and 7,250 acres of wildlife management areas. In the northern basin, public as well as private recreational resources form the basis for a major tourism industry that attracts users from the entire New England region. Seasonal population increases are centered around the Lakes Region, the western basin from Rindge to Andover, and Newfound Lake. In the Lakes Region in 1973, local population doubled to 90,000 people with the influx of seasonal residents. While the White Mountain national and state parks include little residential development, they have created the impetus for a significant commercial service industry (NHWSPCC 303(e), 1973 [3110]).

South of Concord, New Hampshire, and in the Massachusetts portion of the basin, natural recreational resources serve the urban centers along the main stem and the Boston metropolitan area. While the natural resources



Outdoor Recreation Areas
Merrimack River Basin

0miles 5 10

BASE MAP SOURCE: USGS HYDROLOGIC UNIT MAP, 1:500,000, 1974; TOWN LINES, NERBC, 1:500,000, 1976.

19
MAP NO.

in the southern basin may not be as outstanding as those further north, the cultural and historical resources have for many years provided recreational opportunities. It is significant that the only major proposed recreational development in the basin, the Lowell State Heritage Park and Lowell National Urban Cultural Park, includes a focus on the historic resources represented by the Lowell canals and the Merrimack River.

The distribution and magnitude of outdoor recreational demand, the types of activities in demand, and the resources or facilities necessary to meet demand have been identified on a statewide basis in the Statewide Comprehensive Outdoor Recreation Plans (SCORPs) of Massachusetts and New Hampshire. According to the findings of these plans, demand for water related recreation, nonpool swimming, motorboating, fishing, sailing, canoeing, will continue to rise in the basin. However, the largest unmet demands for outdoor recreation are generally not for water related activities. Only two planning areas in New Hampshire, the Lakes Region and southeastern New Hampshire, identified a water related activity (swimming beaches) as a high priority need. For the five planning regions covering the basin in Massachusetts, the capacity of existing recreation areas, as a percentage of 1977 demand, was under 50% for motor boating and fishing in all regions. Similar capacity for nonpool swimming exists in the three western most regions and for canoeing and sailing in the Lowell and Boston Metropolitan Area. These figures include estimations of out of state visitors. They do not reflect saltwater activities which constitute significant opportunities in the two coastal regions. The only critical need identified by the Massachusetts SCORP in the five regions is for fishing waters in the southwestern region V (see Regional Jurisdictions, Map 9).

In most of the basin, the problem in meeting demand is not lack of water resources so much as limited access to or facilities for those that exist. In Massachusetts, use restrictions imposed on water supply reservoirs, such as Wachusett and Sudbury, are a major constraint to meeting the demands for access (Massachusetts DEM, 1976 [3602]).

Plans and Programs. Major recreational planning efforts are undertaken by Massachusetts Department of Environmental Management (DEM) and New Hampshire Departemnt of Resources and Economic Development (DRED) as an eligibility requirement for the Land and Water Conservation Fund

administered by the Bureau of Outdoor Recreation. Based on the analysis of recreation demands and needs, both states have established as policy, the goal of responding to unmet metropolitan demands and, for Massachusetts, the goal of preserving unique natural areas. Massachusetts and New Hampshire are also currently participating in a six state Regional Demand Study that will establish a framework for predicting out-of-state demand.

The acquisition and development of recreational resources is directed by 1) the demand studies; 2) policies to protect water resources of special criticality or significance, such as wetlands, streambanks, rivers, and other surface waters; and 3) policies to maximize the impacts of investments through the development of regional, multiple-use recreation areas. In the basin, the application of the latter policy is exemplified by the White Mountain national and state park systems (existing) and the state and federal parks at Lowell (under development and proposed). Both states have also completed in-depth inventories of existing recreational facilities.

While no basin rivers are current candidates for inclusion in the federal Wild and Scenic Rivers system, both states have been involved, to differing degrees, in river protection efforts. Although no formal program currently exists , the New Hampshire Office of Comprehensive Planning (OCP) has, with the help of the Appalachian Mountain Club, completed preliminary identification of wild, scenic, and recreational rivers in response to a policy (enacted by the New Hampshire General Court in 1971) to preserve and protect outstanding state rivers. The resultant report also recommends the enactment of state legislation to direct the development of a rivers program and identifies existing planning and regulatory techniques that could be applied to river management (Urban Research and Development Corp., 1977 [3619]).

The Massachusetts DEM is currently implementing the state Scenic Rivers Act through nomination of potential candidates and the development of a demonstration river management plan on the North River. While the Act authorizes the Commissioner to adopt orders regulating alteration of lands within 100 yards of a designated river, and to acquire by eminent domain those lands for which orders would constitute a taking, no orders have been issued to date. Basin rivers proposed for inclusion under both states' programs are shown on Map 19.

Table 17: Selected Natural Areas

NAME	LOCATION	OWNERSHIP
New Hampshire		
Profile Lake	Franconia	state
Greeley Ponds	Livermore	federal
Nissitissit River	Brookline	private
Newfound Lake	Hebron	state/private
Pow-Wow River Valley	Kingston	unknown
Black Gum Swamp	Hillsboro	unknown
Massachusetts		
Concord Battlefield Area	Concord	federal/state/ private
Walden Pond	Concord	state
Longfellow's Wayside Inn	Sudbury	private
Lawrence Canals	Lawrence	unknown
Middlesex Canal	Billerica, Chelmsford, Lowell	unknown
Heald Pond	Pepperell	local/private
Paradise Ravine	Shirley	private

Source: New England Natural Resources Center, undated [3642]

The Clean Water Act of 1977 will also give additional impetus to recreational and open space use of river corridors. The recent ammendments dictate that analyses of recreational and open space opportunities generated by water quality improvement programs must be included in 201 and 208 planning efforts.

Concurrent with recreational management efforts, the states often seek to protect water resources of special significance. Both states depend on a variety of existing programs at the federal, state and private level. Federal and state wetlands protection programs, and state scenic river and critical areas programs are representative of this resource protection network. Massachusetts DEM is in the process of establishing a Heritage Program which will focus on unique natural and cultural areas. The Nature Conservancy, under contract to the DEM, will inventory these sites and start-up a state designation system. The system is designed to compliment the state scenic rivers and National Landmarks programs. Private initiative has also played an important role in resource protection in the case of the Nashua River Greenway plan (Roy Mann Associates, 1970 [3632]). The Nashua River Watershed Association marshalled local and regional support for the acquisition and conservation of the river corridor as a means of preserving the multiple values of this resource. In addition, the Natural Areas Project initiated in 1970 by the New England Natural Resources Center provides the basis for the development of resource protection programs (see Table 17).

Findings and Recommendations. While extensive public and private recreation opportunities exist throughout the basin, rising demands for water related recreation from in-basin SMSAs and the Boston metropolitan area are creating pressures for additional facilities. Planning for further development should respond to the following concerns.

- The private tourism industry provides extensive recreational services and comprises an important component of the basin's economy, particularly in New Hampshire. Yet past recreational planning has largely ignored the role of the private sector in satisfying demands.
- Although the large unmet demand for motorboating and fishing occurs in the southern basin, the opportunities are concen-

trated in the northern and western basin. Recreational planning for these activities should be oriented to rectifying this disparity.

- While the negative impacts of private recreational and other development activity on resource values are recognized, the state recreation planning agencies are generally unable to control these impacts. The incipient wild, scenic and recreational rivers programs and increased coordination of water resource protection efforts offer the primary means of controlling undesirable impacts.

Planning. A positive approach is required to guide New Hampshire's tourist industry, in order to foster continued growth of this important sector of the state's economy, to satisfy unmet recreational demands, and to protect and preserve the recreational resource base. *The products of the Regional Demand Study should be analyzed and interpreted to predict the types and magnitude of future recreation demands and tourist service needs. New Hampshire should consider supporting this effort so as to:*

- *provide guidance to the private sector in the development of service facilities and recreational opportunities; and*
- *evaluate the impact of additional development on the region's natural resources as a means of avoiding the degradation caused by excessive and undirected development.*

Massachusetts should continue to develop basin resources to satisfy the unmet demand for water related recreation in eastern Massachusetts. As a conterpart to the state's inventory of existing facilities, it should conduct a more detailed evaluation of both the recreation potential of basin waters and the impacts of development on these resources. In keeping with its policy to develop multiple-use regional facilities, Massachusetts should consider building upon the existing centers at Newburyport, Lowell, Concord, and the Nashua River.

Recreation planning efforts in both states should utilize the information generated by 201 and 208 programs relative to recreation and open space opportunities. These analyses, in conjunction with ongoing inven-

tories of recreation facilities and access points, should be used to direct acquisition programs.

Both states are pursuing river recreation planning through different but comparable wild, scenic, and recreational river programs. *New Hampshire and Massachusetts should consider integrating recreational planning techniques, such as user preference and resource capability studies, and facilities programming into their management plans for designated rivers. They should consider developing a cooperative approach to recreational planning for designated interstate rivers.*

Action. The wild, scenic, and recreational rivers programs of both states represent a positive and innovative approach to preserving the multiple values of river corridors. *New Hampshire should consider acting upon previous recommendations (Urban Research and Development Corp., 1977* [3619]*) in passing legislation to establish policies, designation processes, and implementation techniques for a rivers program. Massachusetts should be encouraged to coordinate its Scenic Rivers program with other resource protection programs to avoid redundant regulations.*

The proposal for a National Urban Cultural Park at Lowell, Massachusetts, as developed by a special Congressional commission, represents an exciting approach to preserving and presenting to the public the physical and social history of a city. *The National Park Service and Congress are encouraged to take positive action in making this park a reality.*

4.7.5 Mineral Extraction

Existing Conditions. Mineral extraction in the Merrimack basin consists primarily of sand, gravel, crushed and dimension stone production. While New Hampshire was one of the largest producers of feldspar in New England, the development of substitute products has caused a decline in this industry. The major centers of granite production occur in south central New Hampshire around Concord and Milford. Sand and gravel deposits are widely distributed throughout the basin, but closely correspond to the deposition of glacial material in river valleys. Because of the high transportation costs of sand and gravel, extraction typically occurs near developing areas, as in Middlesex County where the value of mineral production ran three to six times higher in 1969 than other basin counties (NAR App. H, 1972 [3611]).

Minerals production is expected to increase slightly in the basin in the future, but at a rate slower than the country as a whole (NAR App. H, 1972 [3611]). Extraction of basin minerals has two major potential impacts on water resources: nonconsumptive use of waters during processing and degradation of water quality in streams receiving runoff or processing discharges. The demand for water by the minerals industry was projected to be approximately 12 mgd by 1980 in the basin (NAR App. H, 1972 [3611]). The same source stated that related water quality problems did not appear to be widespread or persistent. This is corroborated by 208 water quality plans in the basin. In many cases, industries have taken the initiative in developing settling basins, in recirculating water, and in applying other management practices.

Plans and Programs. Localized water quality problems stemming from processing waters or overland runoff are dealt with through EPA's NPDES permits program when necessary. Neither Massachusetts nor New Hampshire regulate extraction at the state level. The degree to which local governments regulate siting and performance of these industries is variable and, to a large extent, unknown.

The USGS has produced areal surveys of existing resources, including statewide mineral investigations maps (exclusive of clay, sand, gravel, and peat deposits) for New Hampshire and Massachusetts, and a series of surficial and bedrock geology investigations which are, however, incomplete for the basin. The U.S. Bureau of Mines conducts research in minerals processing and extraction, and conducts mineral surveys on a cooperative basis with the states.

Two minerals advisory boards in New Hampshire counsel the Department of Resources and Economic Development and the Governor on minerals related matters, such as the direction of survey and mapping efforts.

Findings and Recommendations. Given the low level of water related impacts and limited industry growth, minerals extraction does not represent a major basin concern. However, planning for the location of future sand, gravel, and stone extraction can be of value in identifying where supply shortages may occur and in identifying where mineral extraction will be preempted by rapid growth patterns. *Both Massachusetts and New Hampshire should consider developing programs in mineral resource planning and management that would include the inventorying of sand, gravel, and stone resources.*

5.0 River and Shoreland Uses

The Merrimack River and its shorelands have historically served as the focus of interest for a variety of human activities which took advantage of the unique attributes of this resource. It is the hypothesis of this final section that interest in this resource, long dormant, has been rekindled after almost 50 years of effort to clean up the river's waters. In addition to the traditional uses of this area, the cleaner water makes possible a host of new or reestablished uses. The concentration of these growing demands in the river and shoreland area creates a climate of potential competition which threatens the hard won gains of the water quality program.

An opportunity exists now to safeguard the resource values and the enormous investments of public and private dollars which are represented by water quality improvements. Balanced management of the natural resources represented by the river and its shorelands can provide for the allocation of these new resource potentials.

5.1 AN HISTORICAL PERSPECTIVE

The historical development of the Merrimack (discussed in Section 3.2.1) generated a series of demands on various basin resources, most notably on the river itself. These represent the interaction of physical, socioeconomic, and political factors. Early on, the river provided the easiest transportation routes as well as a bountiful supply of fish and game. Its flood plains also had the most arable soils. The settlement of these lands, under the influence of the river's resources, established a cultural overlay on the landscape which represented a focus on the river and its shorelands. Growing populations and the development of a water

powered manufacturing industry served to generate some of the first major use conflicts. Increasing agricultural and forestry activity resulted in extensive erosion and sedimentation at a time when the newly developed hydropower dams exacerbated these impacts on the river's fisheries and water quality.

Despite these negative impacts, the river still played a critical role in the development of the basin. The growing industrial base and population centers required ever larger supplies of process and drinking water. Perhaps just as importantly, the need for effective industrial and municipal waste disposal grew apace. For a time, at least, the Merrimack and its tributaries were able to meet these demands and serve as a central axis for the social infrastructure of the basin.

Inevitably, the pressures on the river's resources began to expose serious conflicts between traditional water uses. In the absence of active multiple use management, waste disposal, power generation and process water supply became dominant uses, precluding a host of existing uses and, to some extent, limiting the future potential of the river. Up to this point the river proper had played an important, visible role in the lives of the basin's residents. It provided food, recreation, water supply and, in many cases, a livelihood. With a shift to a few exclusive uses, the people living along the river began to disregard and even avoid it.

Finally the river was degraded to such an extent that it no longer was able to meet some of the most basic demands and, in fact, was becoming a public nuisance. In the 1930s, a series of efforts was initiated, continuing through the present, which attempted to restore the quality of the river's waters and control the wastes discharged into it. While these efforts were first focused only on major municipal discharges, it has become clear that a wide variety of human activities in the shoreland area directly and indirectly affect the water quality and resource potential of the river. The water quality program today represents a public and private investment of millions of dollars and a commitment by government agencies at all levels to years of continued management.

These decades of effort have had substantial success and today it is apparent that, once again, the river will be able to support a multitude

of uses. The demand for water, however, has greatly increased in the ensuing years and the management problems today are, if anything, much more difficult than before.

5.2 DEMANDS ON THE RESOURCE, NEW AND OLD

While the opportunities created by clean water have set the stage for an exciting new period in the Merrimack's history, a variety of ongoing and new uses will create mounting demands on the resources.

Ongoing demands center around the historically dominant uses of the river; waste disposal, industrial water supply and power generation. As a result of water pollution control efforts, the limitations on both industrial and municipal waste disposal are becoming increasingly stringent. The need for effective waste disposal has, however, grown in conjunction with the expanding population of the area. While industrial water supply options were partially limited by the historically low water quality, the cleaner waters may now serve as an important economic resource and stimulus. The hydropower facilities which supported the industrialization of the basin's economy were largely supplanted by inexpensive fossil fuels. Recent increases in the cost of these fuels has renewed interest in the redevelopment and expansion of hydroelectric facilities along the Merrimack.

In addition to these traditional river and shoreland uses, a variety of new or reestablished uses have also been made possible by the water quality improvements. There is evidence in several portions of the basin that the value of waterfront property for commercial and residential development is increasing. Additional efforts are being mounted to conserve the new recreational and open space opportunities which are coming into being in this area. The improved quality of fish and wildlife habitat has increased potential management options including the possibility of restoring an anadromous fishery in the Merrimack. The population growth along the southern main stem and its tributaries, while increasing the need for waste disposal options as mentioned earlier, has also generated a large demand for domestic water supply. Limited but important water supplies are now developed from the Merrimack at considerable expense. Further improvements in water quality, however, may have the result of lowering the cost of water supply development, increasing the attractiveness of the resource.

Taken as a group, these water and land uses constitute an interrelated set of demands on the resources of the river and its shorelands. The competition among these uses creates the need for a comprehensive approach to resource management in this area. The primary goal of such management must be to maintain water quality improvements as a prerequisite to any further diversification and increase of river and shoreland uses. The key to this management lies in recognition of the overlap between the available tools. Efforts to conserve flood plains, wildlife habitat, wetlands, scenic areas, and recreational opportunities tend to focus on the same geographical areas, thus indirectly identifying the development potential of other, adjacent areas. Management of flow dependant uses involves similar overlap.

The components of a management framework which might deal with the Merrimack corridor exist in both states and at the federal level.

5.3 EXISTING MANAGEMENT OF THE RIVER AND ITS SHORELANDS

The programs and initiatives described below are representative of the active interest now being taken in the river and shoreland area. Although not an exhaustive listing, these examples do describe a potential management framework at all levels of government which could be coordinated to provide the necessary comprehensive effort. These programs are described in greater detail in the preceeding chapters.

At the local level, interest has been expressed in developing waterfront parks as well in renovating commercial, urban waterfronts. Haverhill and Newburyport are employing federal and state community development assistance to renovate their waterfronts. Lowell will be the site of a state heritage park and a national urban cultural park which will highlight the water based mill complexes and the related canal systems. Town governments including conservation commissions and planning boards also have the ability to regulate shoreland development under the auspices of flood plain bylaws and wetland regulations. The basic zoning and subdivision controls are indicated, by town, in Map 11. These town bodies have also joined with private groups to initiate greenway acquisition programs on a multitown basis.

At the substate, regional level, several private river and watershed associations have been working to publicize various water issues and to improve public access to the river. These groups include the Nashua River

Watershed Association, the Merrimack Valley Watershed Council, the Nissitissit Land Trust, and the Lakes Region Clean Water Association. Several of these groups also participate regularly in the planning and management activities conducted by government agencies. One such activity, particularly relevant at this level, is the Section 208 planning being conducted by several regional planning commissions. Working with the states, these agencies are preparing areawide water quality management plans, a portion of which involves identifying the potential public benefits of improved water quality, specifically, in the form of open space and recreational opportunities.

Both New Hampshire and Massachusetts are conducting programs which deal in whole or in part with specific aspects of the river and shoreland resources. The scenic rivers program in Massachusetts and a similar initiative in New Hampshire are the most obvious examples of this. Massachusetts has also taken steps to implement the Unified National Program for Flood Plain Management which entails a comprehensive approach. The states are jointly involved with the federal government in an anadromous fish restoration program which deals with the Merrimack River system as a whole.

At the federal level, many programs are ostensibly oriented toward river basin management. Those that have direct relevance for the Merrimack and its shorelands can be briefly described. The Clean Water Program, conducted by EPA, is administered on the basis of states and river basins. Aspects of this program deal directly with land use activity along shorelines and their potential water quality impacts. EPA is also developing guidelines with the Heritage Conservation and Recreation Service (HCRS) to implement the 1977 Clean Water Act requirements for recreation and open space. HCRS is also studying a 22 mile segment of the Pemigewasset River under the auspices of the Federal Wild and Scenic Rivers program. The Unified National Program for Flood Plain Management, developed by the Water Resources Council, is a third program focusing on planning and management of the river and its shorelands.

Although many of these programs are complementary and, as pointed out earlier, often deal with the same natural resource values or areas,

there is now only limited coordination. The comprehensive management which such coordination would allow, is sorely needed. After a long period of neglect, the river's resources can again support a myriad of uses and again become a central axis for the basin. As growing and diverse demands are placed on the river, it is essential that, in the management of its resources, an attempt be made to integrate the objectives of each management effort. *In view of the interstate nature of the basin and the potentially conflicting demands, such integration and comprehensive management can only occur as the result of an undertaking by both states and federal agencies to actively coordinate their activities.*

Appendix A

Bibliography and Guide to Data Profile

APPENDIX A Guide to Data Profile

The data profile is designed to provide a survey of basic information sources and a systematic process for reporting the availability and status of natural resources data. The profile is based on the following objectives:

- to provide improved documentation of information sources used in developing the basin overviews;
- to organize sources of baseline natural resources information in a format that can be used as a foundation for subsequent studies of the basin; and
- to provide an improved assessment of data availability to sharpen data collection recommendations in the overview.

The system is composed of four cross-referenced records that lead interested readers to progressively more detailed descriptions of data sources. The system is not intended to be an exhaustive listing of available sources, although the capacity for expansion and updating has been built in.

As information sources are identified and reviewed, the following record system is used to index and describe each source.

1. Index Table - assigns a four digit reference number to each information source which indicates the relevance of the source to a major data category (e.g. natural resource inventory) and a data element (e.g. soils).

2. Bibliography - two bibliographies are used, an alphabetical listing of all the references, and a numerical listing based on the four digit numbers and organized by the major data categories and data elements.

3. Reference Maps - delineate the geographic coverage of information sources for selected data elements, as well as the date of the reference, and nature (detailed vs. general) of the information reported.

4. Abstracts - abstracts of all referenced sources are filed in a looseleaf binder. Studies annotated in these binders can be referenced through the index table and bibliography.

Only two records, the index table and bibliography, are published with the main report. The reference maps and abstracts are on file at NERBC in looseleaf binders (limited copies are available on request).

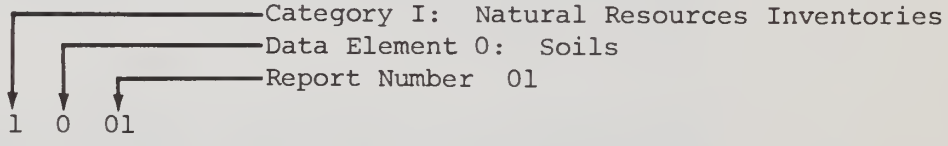
GUIDE TO USING THE PROFILE

The following example illustrates the procedure for using the data profile, using soils as the data element of interest.

STEP 1: THE INDEX TABLE

Categories & Elements	Index Numbers to Bibliography and Abstracts
CATEGORY I: NATURAL RESOURCES INVENTORIES	
Soils	1001 1002 1003
Surficial Geology	1101 1102 1103

As seen above, soils appears as the first data element under Category I: Natural Resources Inventories. The four digit numbers adjacent to soils reference the sources available. These reference numbers are based on the Category and Data Element breakdown of the profile.



An asterisk next to a data element indicates that a reference map is available.

STEP 2: THE NUMERICAL BIBLIOGRAPHY

Numerical Bibliography

	References	Abstract Location
CATEGORY I: Natural Resources Inventories		
Soils 1000 series		
1001	NAR (1972)	1001
1002	USDA-SCS (1977c)	1002
1003	USDA-SCS (undated)	1003

After noting the appropriate reference numbers from the index table, one should refer to the numerical bibliography to find an abbreviated citation for the source and the abstract location. A list of abbreviations precedes this bibliography.

STEP 3: THE ALPHABETICAL BIBLIOGRAPHY AND ABSTRACTS

North Atlantic Regional Water Resources Study Group. North Atlantic Regional Water Resources Study and Appendices A-V, 1972. [1001]

The complete citation for the source (NAR, (1972)) is located in the alphabetical bibliography. The abstract location number is shown in brackets after the citation. For this report the abstract is located under number 1001 in the binder of the abstracts.

As noted earlier, only two of the records, the index table and bibliography, are published with the report. The looseleaf binder of abstracts and reference maps is available at the NERBC offices in Boston (617 223-6244).

APPENDIX A Index to Sources of Data for the Merrimack River Basin

Categories & Elements	Index Numbers to Bibliography and Abstracts
CATEGORY I: NATURAL RESOURCES INVENTORIES	
Soils*	1001 1002 1003
Surficial Geology*	1101 1102 1103
Bedrock Geology*	1201 1202 1203
Surface Water	1301 1302 1303 1304 1305 1306 1307 1308 1309 1310 1311 1312 1313 1314 1315 1316 1317 1318 1319 1320 1321 1322 1323 1324 1325 1326 1327 1328 1329 1330 1331 1332 1333
Ground Water*	1401 1402 1403 1404 1405 1406 1407 1408 1409 1410 1411 1412
Critical Areas	
Natural Areas	1502 1505 1507 1508 1511 1512 1513 1514
Wildlife Management	1502 1504 1508 1509
Wetlands	1501 1504 1506 1508 1509 1511 1512
Rare & Endangered Species	1503 1508
Historical/Cultural	1505 1508 1510
Flood Plain	1504 1508 1509 1511 1512
Cartographic Aids*	
Topographic Maps	1601 1602
Orthophoto Maps	
Aerial Photo Surveys	
CATEGORY II: MONITORING NETWORKS	
Water Availability	
Stream	2001 2002 2003 2004 2005 2006 2007
Lake	2005
Ground	2004 2005
Water Quality*	
Stream	2101 2102 2103 2105 2106 2107 2108 2109 2110 2111 2112
Lake	2103 2104 2105 2107 2112
Ground	2103 2105 2107 2111 2112
Climatology*	2201 2202 2203 2204

* Reference maps available

Categories & Elements	Index Numbers to Bibliography and Abstracts
CATEGORY III: WATER USE & DEMANDS	
Water Supply	
Sources & Facilities	3001 3002 3003 3004 3007 3008 3009 3011 3014 3015 3016 3018 3020 3021 3022 3023 3024 3026 3027 3028 3029
Existing Uses	3001 3002 3003 3005 3008 3009 3010 3011 3017 3020 3021 3023 3024 3026
Projected Demands	3001 3002 3003 3004 3005 3008 3009 3011 3016 3020 3021 3023 3024
Programs	3001 3002 3004 3006 3011 3012 3013 3014 3017 3019 3020 3024 3025 3026
Water Quality	
Classification	3103 3104 3105 3106 3109 3110 3111 3116 3118 3125 3129 3131 3137 3138 3139
Point Discharges	
Municipal	3101 3102 3103 3105 3106 3109 3110 3111 3123 3127 3131 3135
Industrial	3101 3102 3103 3104 3105 3106 3109 3110 3111 3113 3127 3138
Nonpoint Discharges	
Agriculture	3102 3103 3111 3138
Urban Runoff	3102 3112 3123 3137 3138
Forestry	3102 3123 3138
Construction	3102 3123 3138
Mining	3102
Deicing	3102
Hazardous Materials	3102 3138
On-site Subsurface Disposal	3102 3123 3138
Solid Waste Disposal	3102 3103 3120 3121 3123 3138
Other	3102 3122 3123 2138 3139
Wastewater Management	3102 3103 3105 3106 3107 3110 3111 3113 3127 3130 3138

Categories & Elements	Index Numbers to Bibliography and Abstracts
CATEGORY III: WATER USE & DEMANDS (cont.)	
Programs	3101 3102 3103 3104 3105 3106 3107 3108 3109 3110 3111 3112 3114 3115 3117 3118 3119 3120 3123 3124 3126 3128 3130 3131 3132 3133 3134 3136 3138 3140 3141
Flooding	
Damages	3201 3202 3203 3206 3207 3208 3209 3210 3213 3217 3218 3221 3222 3224
Structural Projects	3201 3202 3203 3207 3208 3210 3211 3213 3218
Nonstructural Projects	3202 3203 3204 3208 3210 3211 3213 3218 3223
Programs	3201 3202 3203 3204 3205 3206 3210 3211 3212 3213 3214 3215 3216 3218 3219 3220 3223
Erosion	
Damages	3302 3304 3305 3306
Management Projects	3302 3303 3305 3306
Programs	3301 3306 3307 3308 3309
Navigation	3401 3403 3406 3407
Programs	3402 3403 3404 3405
Fish and Wildlife	3502 3505 3506 3507 3508 3509 3513 3516
Programs	3501 3503 3504 3510 3511 3512 3513 3514 3515 3516
Other Water Related	
Land Use	3601 3611 3618 3627 3628 3631 3632 3634 3637 3642 3643 3644
Forestry	3605 3611 3618 3621 3628 3635 3643 3649
Agriculture	3605 3612 3617 3618 3626 3628 3633 3639 3643
Energy	3601 3605 3606 3610 3611 3616 3620 3622 3630 3648 3650 3652
Recreation	3601 3602 3603 3604 3605 3607 3609 3611 3614 3619 3628 3631 3632 3636 3638 3640 3645 3646 3647 3650 3651
Mineral Extraction	3605
Programs	3601 3602 3607 3608 3611 3613 3615 3623 3624 3625 3627 3629 3641 3643

Categories and Elements	Index Numbers to Bibliography and Abstracts
CATEGORY IV: SOCIO-ECONOMIC	
Population	4001 4002 4003 4004 4005 4006 4007 4008 4009 4010 4011 4012 4013 4014 4015 4017 4018 4019 4020 4021 4022 4023 4024 4025
Economics	4101 4102 4103 4104 4105 4106 4107 4108 4109 4110 4111

Abbreviations

MAPC	Metropolitan Area Planning Council
Mass. EOEA	Executive Office of Environmental Affairs
Mass. CZM	Coastal Zone Management
Mass. DEM	Department of Environmental Management
Mass. DEQE	Department of Environmental Engineering
Mass. DNR	Department of Natural Resources
Mass. OSP	Office of State Planning
Mass. WRC	Water Resources Commission
NE FRC	New England Federal Regional Council
NE NRC	New England Natural Resources Center
NERCOM	New England Regional Commission
NERBC	New England River Basins Commission
NH DRED	Department of Resources and Economic Development
NH OCP	Office of Comprehensive Planning
NH WSPCC	Water Supply and Pollution Control Commission
NAR	North Atlantic Regional Water Resources Study Group
NENYIAC	New England New York Interagency Committee
RPC/A	Regional Planning Commission/Agency
FPC	Federal Power Commission (now: Federal Energy Regulatory Commission)
US Army COE	Corps of Engineers
US DOC	Department of Commerce
US EPA	Environmental Protection Agency
USDA-FS	Department of Agriculture-Forest Service
USDA-SCS	Department of Agriculture-Soil Conservation Service
USDA-BOR	Department of Interior-Bureau of Outdoor Recreation (now: Heritage Conservation and Recreation Service)
USGS	Geological Survey
US WRC	Water Resources Council

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APPENDIX A Numerical Bibliography

	References	Abstract Location
CATEGORY I: Natural Resource Inventories		
Soils 1000 Series		
1001	NAR (1972)	1001
1002	USDA-SCS (1977c)	1002
1003	USDA-SCS (undated)	1003
Surficial Geology 1100 Series		
1101	USGS (1975b)	1101
1102	NAR (1972)	1001
1103	USGS (1975a)	1103
Bedrock Geology 1200 Series		
1201	USGS (1975b)	1101
1202	NAR (1972)	1001
1203	USGS (1975a)	1103
Surface Water 1300 Series		
1301	NENYIAC (1954)	1301
1302	USGS (1977b)	1302
1303	Camp, Dresser & McKee Inc. (1975)	1303
1304	NH OCP (unpublished)	1304
1305	USGS (1977a)	1302
1306	NE RPC (1937)	1306
1307	MAPC (1976)	1307
1308	Roy Mann Associates (1970)	1308
1309	NH Fisheries and Game (1963a)	1309
1310	Metcalf & Eddy, Inc. (1976)	1310
1311	US Army COE (1977b)	1311
1312	NH WSPCC (1973)	1312
1313	NAR (1972)	1001
1314	Mass. DEQE (1976c)	1314
1315	USGS (undated (a))	1315

	References	Abstract Location
1316	US EPA (undated (a))	1316
1317	USGS (1978a)	1317
1318	USGS (1978b)	1318
1319	USGS (1975a)	1103
1320	USGS (1975b)	1101
1321	USGS (undated (c))	1321
1322	NH WSPCC (1978)	1322
1323	Lakes RPC (1978)	1323
1324	Mass. DEQE (1976d)	1324
1325	NH Fish and Game (1963b)	1325
1326	US Army COE (1977c)	1326
1327	US Army COE (1977a)	1327
1328	Jason M. Cortell and Associates (1975)	1328
1329	US Army COE (1965)	1329
1330	US Army COE (1972)	1330
1331	USDA-SCS (1976a)	1331
1332	USDA-SCS (1977a)	1332
1333	US Army COE (undated (b))	1333

Groundwater 1400 Series

1401	NENYIAC (1954)	1301
1402	USGS (1976)	1402
1403	Roy Mann Associates (1970)	1308
1404	US Army COE (1977a)	1327
1405	NAR (1972)	1001
1406	USGS (1977b)	1302
1407	USGS (undated (a))	1315
1408	USGS (1978a)	1317
1409	USGS (1978b)	1318
1410	USGS (1975a)	1103
1411	USGS (1975b)	1101
1412	USGS (undated (c))	1321
1413	USGS (1977a)	1302

Critical Areas 1500 Series

1501	Mass DNR (1967)	1501
1502	Mass DNR (1970)	1502
1503	USDA-SCS (1977a)	1332
1504	Roy Mann Associates (1970)	1308
1505	NH DRED (1975a)	1505

	References	Abstract Location
1506	USDA, Mass. WRC (1977)	1506
1507	NE NRC (undated)	1507
1508	Mass. CZM (1977)	1508
1509	NAR (1972)	1001
1510	Mass. DEM (1978a)	1510
1511	USGS (1978a)	1317
1512	USGS (1978b)	1318
1513	USDA-SCS (1977c)	1002
1514	Mass. DEM (1978b)	1514
1515	USGS (1978a)	1317

Cartographic Aids 1600 Series

1601	USGS (1969a)	1601
1602	USGS (1969b)	1601

CATEGORY II: Monitoring Networks

Water Availability 2000 Series

2001	US Army COE (1972)	1330
2002	NH WSPCC (1973)	1312
2003	USGS (1974)	2003
2004	USGS (1978a)	1317
2005	USGS (1978b)	1318
2006	Jason M. Cortell and Associates, Inc. (1975)	1328

Water Quality 2100 Series

2101	USDA, Mass. WRC (1977)	1506
2102	Camp, Dresser & McKee, Inc. (1975)	1303
2103	USGS (undated (b))	2103
2104	USGS (1974)	2003
2105	US EPA (undated (b))	2105
2106	NH WSPCC (1973)	1312
2107	Mass. DEQE (1975a)	2107
2108	Mass. DEQE (1975b)	2108
2109	Mass. DEQE (1976a)	2109
2110	Mass. DEQE (1975c)	2110
2111	USGS (1978a)	1317
2112	USGS (1978b)	1318

	References	Abstract Location
Climatology		
2201	NENYIAC (1954)	1301
2202	US Army COE (undated (a))	2202
2203	US DOC (1977)	2203
2204	US Army COE (1972)	1330
CATEGORY III: Water Use and Demands		
Water Supply		
3001	Wallace, Floyd, Ellenzweig, Moore, Inc. (1977)	3001
3002	NENYIAC (1954)	1301
3003	Anderson-Nichols and Company, Inc. (1969)	3003
3004	Anderson-Nichols and Company, Inc. (1972)	3004
3005	US Army COE (1974b)	3005
3006	US Army COE (1977c)	1326
3007	NH WSPCC (1973)	1312
3008	US Army COE (1976b)	3008
3009	US Army COE (1977a)	1327
3010	USGS (1970)	3010
3011	Curran Associates (1975)	3010
3012	US Army COE (1977b)	1311
3013	NERBC (1974)	3013
3014	USDA-SCS (1977c)	1002
3015	US Army COE (1965)	1329
3016	US Army COE (1972)	1330
3017	Harry S. Weinroth Associates (1970)	3017
3018	NH WSPCC (1976b)	3018
3019	Northern Middlesex Area Planning Comm. (1977)	3019
3020	NAR (1972)	1001
3021	US Army COE (1975)	3021
3022	USDA-SCS (1970b)	3022
3023	Anderson-Nichols and Company, Inc. (1973)	3023
3024	Curran Associates (1973)	3024
3025	NERBC (1977c)	3025
3026	NH OCP (unpublished)	1304
3027	Jason M. Cortell and Associatesm Inc. (1975)	1328
3028	Roy Mann Associates (1970)	1308
3029	NE RPC (1937)	1306

	References	Abstract Location
Water Quality		
3101	Abt Associates (1975)	3101
3102	Camp, Dresser & McKee, Inc. (1975)	1301
3103	Mass. DEQE (1975a)	2107
3104	Mass. DEQE (1975b)	2108
3105	Mass. DEQE (1976a)	2109
3106	Mass. DEQE (1975c)	2110
3107	Metcalf & Eddy, Inc. (1976)	1310
3108	US Army COE (1977b)	1311
3109	NENYIAC (1954)	1301
3110	NH WSPCC (1973)	1312
3111	NH WSPCC (1976a)	3111
3112	NH WSPCC (1977a)	3112
3113	US Army COE (1974a)	3113
3114	US EPA (1974)	3114
3115	US EPA (1977)	3115
3116	Mass DEQE (1977b)	3116
3117	Mass. DEQE (1976c)	1314
3118	NERBC (1977c)	3025
3119	Mass DEQE (1977a)	3119
3120	Nashua RPC (1973)	3120
3121	McGinn (1977)	3121
3122	NH WSPCC (1978a)	1322
3123	Lakes RPC (1978)	3123
3124	NERBC (1974)	3013
3125	Jason M. Cortell and Associates, Inc. (1975)	1328
3126	NE NRC (1972)	3126
3127	US Army COE (1971)	3127
3128	NH WSPCC (1977c)	3128
3129	US Army COE (1965)	1329
3130	Curran Associates (1973)	3024
3131	NH WSPCC (1978b)	3131
3132	Abt Associates (1974)	3132
3133	US Army COE (1972)	1330
3134	Harry S. Weinworth Associates (1970)	3017
3135	NE RPC (1937)	1306
3136	Northern Middlesex Area Planning Comm. (1977)	3019
3137	Roy Mann Associates (1970)	1308
3138	NAR (1972)	1001
3139	Mass. DEQE (1976d)	1324
3140	Mass. DEQE (1976b)	3140
3141	NEIWPCC (1975)	3141

	References	Abstract Location
Flooding		
3201	NENYIAC (1954)	1301
3202	US Army COE (1977b)	1311
3203	NERBC (1977a)	3203
3204	NERBC (1977b)	3204
3205	NERBC (1974)	3013
3206	NAR (1972)	1001
3207	US Army COE (1965)	1329
3208	US Army COE (1973)	1330
3209	USDA-SCS (1967a)	1332
3210	USDA-SCS (1977a)	3210
3211	USDA-SCS (1977b)	3211
3212	US WRC (1976)	3212
3213	US Army COE (1977c)	1326
3214	USDA-SCS (1977c)	1002
3215	NERBC (1977c)	3025
3216	Anderson-Nichols and Companym Inc. (1967)	3216
3217	NE RPC (1937)	1306
3218	Middlesex Soil Conservation District (1958)	3218
3219	USDA-SCS (1976b)	3219
3220	Merrimack River Valley Flood Control Comm. (1960)	3220
3221	Roy Mann Associates (1970)	1308
3222	USDA, Mass. WRC (1977)	1506
3223	USDA-SCS (1970b)	3022
3224	Thomson (1964)	3224
Erosion		
3301	NERBC (1977c)	3025
3302	USDA-SCS (1977c)	1002
3303	Middlesex Soil Conservation District (1958)	3218
3304	USDA, Mass. WRC (1977)	1506
3305	NAR (1972)	1001
3306	Mass. CZM (1977)	1508
3307	US Army COE (1977b)	1311
3308	NERBC (1974)	3013
3309	US Army COE (1977c)	1326

	References	Abstract Location
Navigation		
3401	Mass. CZM (1977)	1508
3402	NENYIAC (1954)	1301
3403	US Army COE (1977c)	1326
3404	NERBC (1974)	3013
3405	NERBC (1977c)	3025
3406	US Army COE (1976a)	3406
3407	NAR (1972)	1001
Fish and Wildlife		
3501	NENYIAC (1954)	1301
3502	NAR (1972)	1001
3503	Tech. Comm. for Fisheries Management (1977a)	3503
3504	NERBC (1977c)	3025
3505	NH Fish & Game (1971)	3505
3506	Cole (1972)	3506
3507	NH Fish & Game (1963b)	1325
3508	NH OCP (unpublished)	3508
3509	Jason M. Cortell and Associates (1975)	1328
3510	Roy Mann Associates (1920)	1308
3511	US Fish & Wildlife Service (1977)	3511
3512	NERBC (1974)	3013
3513	Mass. Div. Fisheries & Game (1969)	3513
3514	Int'l Atlantic Salmon Foundation (1977)	3514
3515	Tech. Comm. for Fisheries Management (1977b)	3515
3516	NH Fish & Game (1963a)	1309
Other Water Related		
3601	Mass. CZM (1977)	1508
3602	Mass. DEM (1978a)	1510
3603	Mass. DNR (1970)	1502
3604	US Army COE (1977b)	1311
3605	NENYIAC (1954)	1301
3606	NERCOM (1975)	3606
3607	NH DRED (1975a)	1505
3608	NH DRED (1975b)	3608
3609	NH OCP (1976b)	3609
3610	NH WSPCC (1973)	1312

	References	Abstract Location
3611	NAR (1972)	1001
3612	Mass. Agricultural Experiment Station (1976)	3612
3613	Harry S. Weinroth Associates (1970)	3017
3614	US Army COE (1977c)	1326
3615	NERBC (1974)	3013
3616	US Army COE (undated (b))	1333
3617	US DOC (1964, 1969, 1974)	3617
3618	USDA-SCS (1976b)	3219
3619	Urban Research & Development Corp. (1977)	3619
3620	FPC (1972)	3620
3621	USDA-FS (1977)	3621
3622	NE FRC (1976)	3622
3623	Northern Middlesex Area Planning Commission (1977)	3019
3624	NERBC (1977c)	3025
3625	USDA-SCS (1970a)	3643
3626	USDA-SCS (1977c)	1002
3627	Central NH RPC (1972)	3627
3628	USDA, Mass. WRC (1977)	1506
3629	NERCOM (1976)	3629
3630	NE Regional Planning Comm. (1937)	1306
3631	MAPC (1976)	1307
3632	Roy Mann Associates (1970)	1308
3633	Mass. EOEA (1976)	3633
3634	Northern Middlesex Area Planning Comm. (1976)	3634
3635	USDA-FS (1976)	3635
3636	NH OCP (1975a)	3636
3637	NH OCP (1977)	3637
3638	Mass. DEM (1977b)	1514
3639	USDA-SCS (1975)	3639
3640	USDI-BOR (1977)	3640
3641	Lakes RPC (1977)	3641
3642	NE NRC (undated)	1507
3643	USDA - SCS (1971)	3643
3644	Philip B. Herr and Associates (1973)	3644
3645	Montachusett RPC (1976)	3645
3646	Northern Middlesex Area Planning Comm. (1974)	3646
3647	Merrimack Valley Planning Comm. (1970)	3647
3648	H. Zunder and Associates (1970)	3648
3649	Josephson (1974)	3649
3650	US Army COE (1972)	3650
3651	NH OCP (1973)	3651
3652	FPC (1965)	3652

	References	Abstract Location
CATEGORY IV: Socioeconomics		
Population		
4001	NENYIAC (1954)	1301
4002	US DOC (1960, 1972)	4002
4003	US DOC (1950, 1960, 1970, 1975)	4003
4004	NH OCP (1976a)	4004
4005	NH OCP (1975b)	4005
4006	Curran Associates (1973)	3024
4007	USDA, Mass. WRC (1977)	1506
4008	Northern Middlesex Area Planning Comm. (1976)	3634
4009	NAR (1972)	1001
4010	Camp, Dresser, & McKee, Inc. (1975)	1303
4011	Metcalf & Eddy, Inc. (1976)	1310
4012	NH WSPCC (1973)	1312
4013	NH WSPCC (1978b)	3131
4014	US Army COE (1974a)	3113
4015	Wallace, Floyd, Ellenzweig, Moore, Inc. (1977)	3001
4016	Anderson-Nichols and Company, Inc. (1969)	3003
4017	Anderson-Nichols and Company, Inc. (1972)	3004
4018	US Army COE (1976b)	3009
4019	US Army COE (1977a)	1327
4020	Curran Associates (1975)	3011
4021	Anderson-Nichols and Company, Inc. (1973)	3023
4022	US Army COE (1975)	3021
4023	Philip B. Herr and Associates (1973)	3644
4024	Mass. DEM (1978a)	1510
4025	US Army COE (1972)	1330
Economics		
4101	NENYIAC (1954)	1301
4102	US DOC (1960, 1972)	4002
4103	NERCOM (1976)	3629
4104	USDA, Mass. WRC (1977)	1506
4105	Northern Middlesex Area Planning Comm. (1976)	3634
4106	NAR (1972)	1001
4107	Mass. CZM (1977)	1508
4108	Metcalf & Eddy, Inc. (1976)	1310
4109	Wallace, Floyd, Ellenzweig, Moore, Inc. (1977)	3001
4110	US Army COE (1977a)	1327
4111	US Army COE (1972)	1330

Appendix B

Summary of Recommendations

Summary of Recommendations

The following summary of recommendations is addressed to each level of government and to specific agencies where appropriate. In several cases, a series of specific recommendations from the text have been shortened to a single general recommendation here. Parenthetical references to page numbers indicate the location of the original recommendations in the body of the text.

CONGRESS

- Congress should provide additional funding to alleviate the heavy financial burden on local government posed by the requirements of the Safe Drinking Water Act of 1974, and for the planning and development of new or rehabilitation of existing water supply systems. (61-62)

- Congress should provide funding for the implementation of Section 73 of the Water Resources Development Act and for development of state flood plain management efforts. (84-85)

FEDERAL

- The Environmental Protection Agency (EPA) should endeavor to provide effective implementation of 208 management plans by providing funding to the states for continued planning, technical assistance and implementation programs. (75,93)

- EPA should, in cooperation with the states, expedite the completion of the survey of water supply systems required in the Safe Drinking Water Act and should provide all necessary financial and technical assistance to the state and local governments involved. (59)

- The Water Resources Council should continue to develop planning procedures that will assist in the development of optimal solutions to flood plain management problems. (85)

- The Soil Conservation Service (SCS) should accelerate its cooperative programs with the states' agricultural preservation and forestry programs providing adequate soil information, identifying prime agricultural lands, and assisting efforts to mitigate the water related impacts of farm and forest activities. (93, 100)

- The Army Corps of Engineers (COE) and SCS should assist the states to develop a flood plain management plan for the Merrimack River basin. Planning objectives should reflect the basin's unique conditions and problems so that the optimal mix of structural and non-structural solutions can be attained. (84-85)

- The Army Corps of Engineers should investigate the uncertainties surrounding the potential Merrimack diversion to coastal New Hampshire communities within the context of the Southeastern New Hampshire water supply study. (60)

- The U.S. Geological Survey (USGS) should endeavor to complete ongoing groundwater surveys and to initiate, in cooperation with the states and RPAs, additional studies necessary to evaluate groundwater as a source of supply in the southern half of the basin. (60)

- The U.S. Forest Service, under the Renewable Resources Planning Act of 1974, should develop management policies in cooperation with the states, for federal, state, and private forestlands. (97)

- The Forest Service should give special consideration to the unique role New England's National Forests play in providing recreational and non-market benefits, as well as timber, to the region. (97)

INTERSTATE

- NERBC should provide technical information and assistance to the states in the development of a basinwide flood plain management plan. (84)

- NERBC should include in its current hydropower investigations an analysis and review of the cumulative impacts of hydroelectric facilities on the basin's resources. (106)

- The potential role of the Merrimack Valley Flood Control Commission in activating and coordinating state efforts to develop basinwide flood plain management programs should be explored. (84)

- The Atlantic Salmon restoration strategy plan, currently being updated, should provide an accurate picture of the benefits and potential constraints on river uses of a successful restoration. The reevaluation should take into account the demand for and conflicts generated by other uses of the Merrimack including water supply, hydroelectric generation, cooling water for thermal generating stations, and recreation. (88)

STATE

Water Supply

- The states should adopt the comprehensive water resource management programs, recommended by their respective water supply plan reports, within which future water supply planning and development can be conducted. Water conservation practices should be advanced as major objectives within the programs of both states. (58,61)

- The states should be prepared to participate in advanced planning under the principles of arbitration, for the activation of either Merrimack diversion project. (59)

- The states, with the assistance of NERBC, should give early consideration to the interstate agreements necessary for further investigation of diversions from the Merrimack River. (59)

- The New Hampshire Water Resources Board should initiate reservoir studies in the southern half of the state. (60)

Water Quality

- The states should assign high priority to the funding of areawide wastewater management planning in southcentral New Hampshire and the lower main stem area in Massachusetts. (75,93)

- Massachusetts Department of Environmental Quality Engineering should determine the implications of the 1983 water goals for future development in the SuAsCo subbasin. (75)

- The states should consider taking advantage of the PL 92-500 amendments that encourage alternative, innovative and privately owned treatment systems. (75)

- The states and designated 208 agencies should encourage the development and implementation of best management practices for NPS pollution in response to water quality goals and the assimilative capacity of different water bodies. (75)

Flooding

- The states are encouraged to designate a lead agency or establish other coordinative mechanisms providing a basinwide perspective to direct and coordinate federal, state, and local flood plain management programs. (84)

- New Hampshire and Massachusetts should endeavor to assist basin communities in carrying out their flood plain management programs with emphasis on the National Flood Insurance Program and flood preparedness planning. (85)

Fish and Wildlife

- The New Hampshire Water Supply and Pollution Control Commission, Water Resources Board, and the Massachusetts Department of Environmental Quality Engineering, in cooperation with the states' fish and wildlife agencies, should develop and enforce water quality standards, flow requirements, wetlands preservation programs, and encourage current use assessment efforts in order that valuable habitat is conserved and that options for future fisheries are maintained. (89-90)

Erosion

- The states should encourage and assist the adoption of erosion control design standards as part of town zoning and subdivision regulations. (93)

Forestry

- The states should develop comprehensive policies for forest resources management which coordinate existing forest practice regulations, current use tax programs and educational programs. (97)

- The Massachusetts Department of Environmental Management and the New Hampshire Department of Resources and Economic Development should conduct an analysis of the potential for expanded forestry activities with special attention to new local or regional markets and to mechanisms to efficiently manage small ownerships. A review of the effectiveness of present forest practices regulation should be incorporated into this effort. (97)

Agriculture

- New Hampshire should consider the formulation of a state agricultural policy which establishes a management and planning framework within which long term state agricultural goals can be attained. This policy should coordinate the current use tax program, educational/assistance programs and land use inventory efforts. (100)

- In developing agricultural preservation programs, the New Hampshire Department of Agriculture and the Massachusetts Executive Office of Environmental Affairs should evaluate the potential water related impacts of an enlarged and intensified agricultural industry. (100)

Energy

- The states should develop a regional energy planning framework in close cooperation with the private sector and appropriate federal and regional agencies. This effort should identify the criteria for locating new energy facilities and evaluate the potential role of hydropower. (106)

Recreation

- The states should use the products of the Regional Demand Study and their own SCORP programs to:
  - guide private and state development of additional recreational opportunities and services and to
  - evaluate the impact of these developments on the region's natural resources. (112)
- The states should develop and implement scenic rivers programs, taking special care to coordinate this effort with other multiple-use and resource protection programs at federal, state and local levels (wetlands and habitat protection, flood plain management, water quality maintenance, open space programs). (112,113)

SUBSTATE/LOCAL

- The RPAs, Soil and Water Conservation Districts, and towns should cooperate in the implementation of 208 plans, especially in regard to management strategies most appropriately aimed at the local level, such as erosion control standards. Additional technical assistance should be provided by SCS, the agricultural experiment stations and the cooperative extension agents for these efforts. (93, 100)